

Diversity and Spore Abundance of Arbuscular Mycorrhizal Fungi Associated with *Andrographis paniculata* Nees in A Botanical Garden of Amravati, Maharashtra, India

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Abstract

Arbuscular mycorrhizal fungi (AMF) constitute an important component of soil microbial communities and form symbiotic associations with a wide range of terrestrial plants. The present study investigated the diversity, species composition and spore abundance of AMF associated with the rhizosphere of *Andrographis paniculata* Nees in the Botanical Garden of Shri Shivaji Science College, Amravati, Maharashtra, India. Rhizosphere soil samples were collected from three sampling units within the Botanical Garden and examined for AMF spore occurrence and diversity. A total of 31 AMF species belonging to four genera, namely *Acaulospora*, *Gigaspora*, *Glomus* and *Sclerocystis* were recorded. The total AMF spore population was 901. *Glomus* was the predominant genus, comprising 21 species and 864 spores, representing 95.89% of the total spore population. *Acaulospora* comprised eight species and contributed 3.66%, whereas *Gigaspora* and *Sclerocystis* were represented by one species each and contributed 0.22% each. Among individual taxa, *Glomus reticulatum* exhibited the highest relative abundance (12.65%), followed by *G. leptothicum* (9.88%) and *G. fasciculatum* (7.33%). The Shannon-Wiener diversity index ranged from 2.943 to 2.976, while Simpson dominance values ranged from 0.061 to 0.064. The findings demonstrate that the rhizosphere of *A. paniculata* in the Botanical Garden harbours a diverse AMF assemblage characterized by considerable species richness and pronounced dominance of *Glomus*. The study provides baseline information on AMF diversity associated with a medicinal plant in the Amravati region.

Keywords: Arbuscular mycorrhizal fungi; AMF diversity; *Andrographis paniculata*; *Glomus*; spore abundance; medicinal plant; Amravati.

1. Introduction

Arbuscular mycorrhizal fungi (AMF) are important soil-associated symbiotic fungi that establish associations with the roots of a wide range of terrestrial plants. Through their extensive extraradical hyphal networks, AMF contribute to the acquisition of nutrients and water by host plants and play important roles in plant soil interactions. Their occurrence across diverse plant communities makes them an important component of below ground biodiversity. Sundar et al. (2011) documented AMF associations in medicinal plants of southern India and demonstrated considerable variation in AMF species richness, spore abundance and diversity among different host plants and geographical locations. Medicinal plants provide

important habitats for AMF and may support diverse fungal communities in their rhizospheres. Mathew and Malathy (2006) investigated mycorrhizal occurrence in 40 medicinal plants of Kerala and reported AMF colonization across the plants examined, with considerable variation in the degree of colonization among host species. Their findings demonstrated the widespread occurrence of mycorrhizal associations among medicinal plants. AMF diversity can vary considerably according to host plant, geographical location and soil characteristics. In a study of medicinal plants in Kanyakumari District, Sundar et al. (2011) identified 21 AMF species belonging to four genera and found that species richness, colonization and Shannon diversity varied among plants and locations. The authors also reported *Glomus* as the dominant genus and suggested that differences in soil texture, moisture and other edaphic characteristics contributed to variation in AMF communities.

A broader investigation of medicinal plants in southeast China further demonstrated the high diversity of AMF associated with medicinal plant rhizospheres. Zhang et al. (2015) identified 66 AMF species belonging to eight genera from 20 medicinal plant species. *Glomus* represented the largest component of the community, with 38 species, and AMF spore density and species richness varied substantially among host plants. The study also demonstrated relationships between AMF colonization and soil properties, highlighting the importance of environmental conditions in shaping AMF communities. Studies using both morphological and molecular approaches have further demonstrated that AMF communities can differ among soil types. Suchitra et al. (2012) investigated AMF diversity in three tropical soil types of the Coimbatore region of Tamil Nadu and identified *Glomus*, *Gigaspora*, *Scutellospora* and *Acaulospora*. Their results showed differences in AMF diversity among soil types and indicated a relationship between AMF community composition and soil phosphorus availability. The composition of AMF communities is therefore important for understanding the ecological relationships between medicinal plants and their rhizospheric microbial communities. Recent research on medicinal plants has also demonstrated the importance of AMF–plant interactions in plant performance and the production of biologically active compounds. Zhao et al. (2022) reviewed experimental evidence showing that AMF can influence medicinal plants through effects on plant growth and secondary metabolism, although the magnitude of these effects depends on the host plant, fungal strain and environmental conditions. *Andrographis paniculata* Nees, commonly known as Kalmegh, is an important medicinal plant valued for its diverse therapeutic properties. However, information on the diversity and distribution of AMF associated with *A. paniculata*, particularly in the Amravati region of Maharashtra, remains limited. Therefore, documenting the indigenous AMF community associated with this medicinal plant is important for establishing baseline information on AMF biodiversity in the region. The present study was therefore undertaken to investigate the diversity, species composition, spore abundance and distribution of AMF associated with the rhizosphere of *A. paniculata* in the Botanical Garden of Shri Shivaji Science College, Amravati, Maharashtra. Particular emphasis was placed on AMF species richness, relative abundance, genus-level composition and ecological diversity indices.

Objectives

The present study aimed to:

1. document the AMF species associated with the rhizosphere of *A. paniculata*
2. determine AMF spore abundance and relative abundance
3. evaluate genus-level composition and dominance of the AMF community
4. assess AMF diversity using Shannon-Wiener and Simpson diversity indices.

2. Materials and Methods

2.1 Study area

The study was conducted in the Botanical Garden of Shri Shivaji Science College, Shivaji Nagar, Amravati, Maharashtra, India. The investigation focused on AMF associated with the rhizosphere of *Andrographis paniculata*.

2.2 Collection of rhizosphere soil samples

Rhizosphere soil samples associated with *A. paniculata* were collected from three sampling sites within the Botanical Garden. Samples were collected in triplicate to improve the reliability of the observations. The collected soil samples were used for isolation and identification of AMF spores. The three sampling units were designated as BGR-1, BGR-2 and BGR-3.

2.3 Isolation and identification of AMF spores

AMF spores were isolated from the rhizosphere soil samples and identified based on their morphological characteristics. The identified spores were assigned to different AMF taxa and their occurrence was recorded for each sampling site. The study recorded 31 AMF species belonging to four genera: *Acaulospora*, *Gigaspora*, *Glomus* and *Sclerocystis*.

2.4 Determination of spore abundance

AMF spores obtained from the soil samples were counted and expressed as the number of spores per 100 g of soil. The three sampling sites recorded 308, 298 and 295 spores respectively.

2.5 Relative abundance

The relative abundance of individual AMF species was determined from their contribution to the total AMF spore population.

$$\text{Relative abundance (\%)} = \frac{\text{Number of spores of a species}}{\text{Total number of AMF spores}} \times 100$$

2.6 Diversity analysis

AMF community diversity was assessed using:

- Shannon-Wiener Diversity Index (H')
- Simpson Dominance Index (D)
- Simpson Diversity Index ($1-D$)

The Shannon-Wiener index was used to evaluate species diversity and distribution, whereas Simpson's index was used to assess dominance and diversity within the AMF community.

2.7 Statistical analysis

Descriptive statistics including mean, median, minimum, maximum, standard deviation and variance were used to describe the distribution of AMF spores among the three sampling sites.

3. Results

3.1 AMF species richness and composition

A total of 31 AMF species were identified from the rhizosphere of *A. paniculata* in the Botanical Garden. These species belonged to four genera: *Acaulospora*, *Gigaspora*, *Glomus* and *Sclerocystis*.

The species composition comprised:

- *Acaulospora* - 8 species
- *Gigaspora* - 1 species
- *Glomus* - 21 species
- *Sclerocystis* - 1 species

The species-presence matrix showed variation in occurrence of some Acaulospora, Gigaspora and Sclerocystis taxa among BGR-1, BGR-2 and BGR-3, whereas several Glomus species occurred consistently across the sampling units.

3.2 AMF spore abundance

The total number of AMF spores recorded from the Botanical Garden was 901. BGR-1 recorded the highest spore abundance with 308 spores, followed by BGR-2 with 298 spores and BGR-3 with 295 spores.

Table 1. Spore abundance and descriptive statistics of AMF

Parameter	BGR-1	BGR-2	BGR-3
Total spore count	308	298	295
Mean	9.94	9.61	9.52
Median	5.00	8.00	8.00
Minimum	0	0	0
Maximum	40	36	38
Standard deviation	9.97	9.25	9.66
Variance	99.33	85.65	93.32

The highest maximum species-level spore count was recorded in BGR-1 (40), followed by BGR-3 (38) and BGR-2 (36). The relatively high standard deviation and variance indicate substantial variation in spore abundance among individual AMF taxa.

3.3 Relative abundance of AMF species

Marked differences were observed in the relative abundance of individual AMF taxa. Glomus reticulatum was the most abundant species, with 114 spores, corresponding to 12.65% of the total AMF population. G. leptothicum ranked second with 89 spores (9.88%), followed by G. fasciculatum with 66 spores (7.33%). Other relatively abundant species included G. tortuosum (6.44%), G. fecundisporum (5.99%), G. heterosporum (5.88%), G. maculosum (5.88%), G. glomerulatum (5.22%), G. geosporum (4.99%) and G. ambisporum (4.44%). In contrast, several species occurred at very low abundance. Acaulospora morrowae, A. rehmanii, A. undulata, Gigaspora decipiens and Sclerocystis sinuosa each contributed only 0.22% of the total spore population.

3.4 Genus-level distribution

The genus-level analysis demonstrated a strong numerical dominance of Glomus.

Table 2. Genus-level composition of AMF

Genus	Number of species	Total spores	Relative contribution (%)
Acaulospora	8	33	3.66
Gigaspora	1	2	0.22
Glomus	21	864	95.89
Sclerocystis	1	2	0.22
Total	31	901	100.00

Glomus accounted for 95.89% of all recovered spores and included 21 of the 31 identified species. Acaulospora contributed 3.66%, whereas Gigaspora and Sclerocystis each contributed 0.22%. This represents the major ecological pattern of the study: species-level diversity was relatively high, but the community was strongly dominated by the genus Glomus

3.5 Diversity indices

The Shannon-Wiener diversity index varied only slightly among the three sampling units.

Table 3. Diversity indices of AMF

Diversity index	BGR-1	BGR-2	BGR-3
Shannon-Wiener (H')	2.943	2.976	2.944
Simpson dominance index (D)	0.064	0.061	0.064
Simpson diversity index (1-D)	0.936	0.939	0.936

BGR-2 exhibited the highest Shannon-Wiener value (2.976), whereas BGR-1 and BGR-3 showed values of 2.943 and 2.944, respectively. Simpson dominance values ranged from 0.061 to 0.064, while Simpson diversity (1-D) ranged from 0.936 to 0.939. The relatively small differences among the three sampling units indicate broadly comparable AMF diversity within the Botanical Garden.

3.6 Dominant AMF species

The ten most abundant AMF species were all members of the genus Glomus. The most abundant was *G. reticulatum*, followed by *G. leptothicum* and *G. fasciculatum*

Table 4. Ten most abundant AMF species

Rank	Species	Total spores	Relative abundance (%)
1	<i>G. reticulatum</i>	114	12.65
2	<i>G. leptothicum</i>	89	9.88
3	<i>G. fasciculatum</i>	66	7.33
4	<i>G. tortuosum</i>	58	6.44
5	<i>G. fecundisporum</i>	54	5.99
6	<i>G. heterosporum</i>	53	5.88
7	<i>G. maculosum</i>	53	5.88
8	<i>G. glomerulatum</i>	47	5.22
9	<i>G. geosporum</i>	45	4.99
10	<i>G. ambisporum</i>	40	4.44

The dominance pattern demonstrates that the most abundant component of the AMF community was represented by several *Glomus* taxa rather than by a single species alone.

4. Discussion

The present study revealed a diverse AMF assemblage associated with *A. paniculata* in the Botanical Garden of Shri Shivaji Science College, Amravati. Thirty-one AMF species belonging to four genera were identified, demonstrating substantial taxonomic diversity within the rhizosphere. The number of AMF taxa recorded in the present investigation is comparable with observations from other Indian medicinal plant

systems. For example, Sundar et al. reported 21 AMF species associated with three medicinal plants in Kanyakumari District, while Radhika and Rodrigues reported 42 AMF species belonging to five genera in medicinal plants of the Western Ghats of Goa. A particularly important feature of the present study was the dominance of *Glomus*. The genus represented 21 of the 31 identified species and accounted for 95.89% of the total spore population. Similar dominance of *Glomus* has been reported in medicinal-plant studies from different regions of India. Studies from Sagar, Kanyakumari and the Western Ghats have likewise identified *Glomus* as the predominant AMF genus. The predominance of *Glomus* in the present study is therefore consistent with observations from several Indian ecosystems. However, the present data also demonstrate that dominance at the genus level does not necessarily imply low species diversity. The Botanical Garden contained 21 *Glomus* species, together with eight *Acaulospora* species and representatives of *Gigaspora* and *Sclerocystis*. Among individual species, *G. reticulatum* showed the highest relative abundance at 12.65%. The relatively high abundance of *G. leptothicum*, *G. fasciculatum* and other *Glomus* species further contributed to the overall dominance of the genus. The Shannon-Wiener diversity values ranged from 2.943 to 2.976, with BGR-2 showing the highest value. The relatively narrow range suggests that the three sampling units supported broadly comparable AMF diversity. The high Simpson diversity values (1-D) further indicate that the AMF assemblage contained numerous taxa rather than being completely dominated by a single species. Interestingly, the present study demonstrates high species diversity together with strong genus-level dominance. This distinction is important when interpreting AMF communities: although *Glomus* accounted for most of the spores, several *Glomus* species contributed to the community, while additional genera occurred at lower abundance. Comparable patterns have been reported in Indian medicinal-plant ecosystems, where *Glomus* frequently represents the dominant genus despite the occurrence of other AMF taxa. The present findings therefore contribute to the growing evidence that medicinal-plant rhizospheres can harbour diverse AMF communities and that *Glomus* frequently forms an important component of these communities.

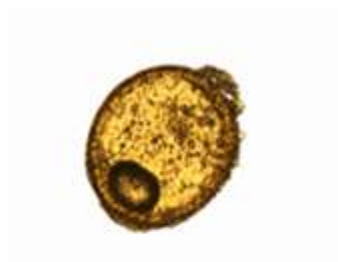
5. Conclusion

The present investigation documented a diverse AMF community associated with *Andrographis paniculata* in the Botanical Garden of Shri Shivaji Science College, Amravati. A total of 31 AMF species belonging to four genera were recorded from the rhizosphere. The AMF community was strongly dominated by *Glomus*, which comprised 21 species and 95.89% of the total spore population. *Glomus reticulatum* was the most abundant individual species, contributing 12.65% of the total spores. The Shannon-Wiener index values of 2.943-2.976 and high Simpson diversity values demonstrated considerable diversity within the investigated AMF community. The study provides baseline information on the composition and abundance of AMF associated with *A. paniculata* in the Amravati region and contributes to the documentation of AMF biodiversity associated with medicinal plants in central India.





G. glomerulatum



G. maculosum



G. geosporum



G. tortuosum



G. fecundisporum



G. heterosporum



G. ambisporum

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