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Natural Occurrence and Distribution of Arbuscular Mycorrhizal Fungi: A Review

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ABSTRACT: Arbuscular mycorrhizal (AM) association constitutes an important component of soil microbial community belongs to the fungal phylum Glomeromycota. They improve plant growth, nutrient uptake, promote plant diversity, help in rehabilitation and reclamation of waste land, biohardening, phytoremediation, soil aggregation and also help to control plant pathogens. Their diversity and composition vary among different habitat of the globe. They occur in a wide spectrum of agricultural crops, most shrubs, tropical tree species and some temperate tree species. It has been found in some gymnosperms, pteridophytes, bryophytes and in some floating and submerged aquatic plants. It is important to study biodiversity of such beneficial fungi from efficient utilization and conservation point of view.

Keywords: Arbuscular mycorrhizal fungi; biodiversity and Soil microbial community.

INTRODUCTION: Arbuscular mycorrhizal (AM) fungi are ubiquitous plant root symbionts that can be considered as 'keystone mutualists' in terrestrial ecosystem, forming a link between biotic and abiotic ecosystem components via. carbon and nutrient fluxes that pass between plant and fungi in the soil[1]. AM fungi are mysterious and surprising organisms that probably appeared on the earth about 400 million years ago and in the meantime became very widespread, being present in the vast majority of ecosystems[2]. Arbuscular mycorrhizal fungi (AMF) are known as the largest component (mycelia and spores) of the microbial biomass in soil. It has been suggested that they play an important ecological role in determining plant biodiversity and species composition in terrestrial ecosystems[3 & 4]. Likewise, the composition of AM fungal communities may be affected by plant diversity[5 & 6].

The diversity and composition of AM fungal communities vary among habitat type among the globe. Adverse environmental conditions can negatively affect the infectivity and survival of AM fungal propagules from one period of root growth to the next[7]. The distribution of certain AM fungal species as well as colonization by AMF associated to a specific plant host has been related to soil pH, phosphorus level, salinity, vegetation and season, shade, host dependence, age of plant[8, 9 & 10]. Furthermore, agricultural practices like tillage, crop sequence and application of chemicals alter AM fungal population, species composition and root colonization[11 & 12].

PLANT FUNGAL RELATIONSHIP: The characteristics and dynamics of occurrence of AM fungi under natural conditions are important for the evaluation of inoculums potential and root colonization in the process of understanding their behaviour on the soil and determining their symbiotic efficiency. The presence or absence of AM fungal spores show that these species may be active in soil at a specific time, being capable of colonizing and multiplying themselves in the plant host roots. AM fungi are not host specific, therefore, several AMF may colonize one host plant and a specific fungus may be associated with different host plants. Moreover, a single AM fungal propagule may be differed in their behaviour to react with two different host plants. Anatomical characters of roots are thought to be influenced by AM morphology[13]. However, Kubato *et al.*[14] indicated that the morphology of AM type is the result of interaction between both the plant and the fungal species. AM fungi produce extraradical hyphal networks and their hyphae contain and release glomalin, which is a putative glycoprotein that is also correlated with improvement in soil structure. Once the roots are colonized by AMF, plants appear to be able to regulate further colonization and the seedlings become quickly mycorrhizal if the soil is full of mycorrhizal hyphae[15]. Different structures like mycelium, vesicles and arbuscules are associated with mycorrhizal root colonization. Arbuscules help in exchange of nutrients between plant and fungus while the vesicles used as storage organ. Knowledge about the presence and diversity of AMF is an essential first step to utilize these fungi in any application.

DISTRIBUTION OF AM FUNGI: AM fungi are ecologically important root symbionts of most terrestrial plants. The International Bank of Glomeromycota states, “The majority of plants, strictly speaking, don’t have roots, they have mycorrhizas. The study of plants without their mycorrhizas is the study of artifacts” (IBG http://www.bio.ukc.ac.uk/ber/).

Although, in last few decades, many researchers have conducted studies on natural association of AM fungi to find out their diversity in different types of vegetation. A widespread occurrence of AM fungi in association with medicinal and aromatic plants of Western Ghat, Southern India has been well documented[16 & 17]. Sudha and Ammani[18] studied the AM fungal association in fifty seven medicinal plants in Thrissur district, Kerala and reported four genera of AM fungi (*Glomus, Gigaspora, Acaulospora* and *Sclerocystis*) in different places. Parkash *et al.*[19] studied the endomycorrhizal association of khair (*Acacia catechu*) and reported four genera of AM fungi (*Glomus, Acaulospora, Gigaspora* and *Sclerocystis*) in rhizosphere of this plant. Twenty three different species of AM fungi belonging to five genera were reported in some ornamental plants of Solan[20]. Khare[21] while worked on *Carica papaya*, reported six species of AM fungi associated to this plant. Diversity of AM fungi in some medicinal plants of Pantnagar, Uttarakhand was studied by Gupta *et al.*[22]. Kumar *et al.*[23] also studied the species diversity of the genus *Glomus* in some medicinal important plants of Himachal Pradesh. Similarly, Sharma *et al.*[24 & 25] reported the different species of *Glomus* and *Acaulospora* associated in the rhizosphere of sunflower in Haryana, India. Twenty four species of AM fungi has been well recognized in rhizosphere of some medicinal plants of Himachal Pradesh[26]. Variation in AM fungal dynamics in five medicinal plant species has been well documented[27]. Varalaxmi *et al.*[28] investigated some plants of cucurbitaceae for AM fungal association and registered thirty five AM fungi associated with these plants. Similarly, fifteen medicinal and ornamental plants belonging to asclepiadaceae were examined for AM fungal association and twenty nine AM fungi associated with these plants were identified up to species level[29]. Sharma *et al.*[30] while worked on biodiversity of AM fungi with some medicinally important plants of Himachal Pradesh, registered thirty nine AMF species belonging to four genera of which *Acaulospora* was predominant followed by *Glomus, Gigaspora* and *Sclerocystis*. Three solanaceous vegetable crops were examined for AM fungal association and fifteen species of AM fungi were registered[31]. Pindi *et al.*[32] studied the distribution and occurrence of AM fungi in polluted soil and found that *Glomus* and *Acaulospora* species were not significantly affected by the effluents. Eleven AM fungi belonging to *Acaulospora*, *Gigaspora* and *Glomus* were extracted from *Eucalyptus tereticornis* and *Eucalyptus camaldulensis*[33]. Different species of *Gigaspora* and *Glomus* from Goa were reported by Khare[34 & 35]. Status of AM fungi in lime quarries and degraded forests was investigated and less number of AM flora was reported in lime quarries than degraded forests[36]. Occurrence of AMF in rhizosphere of medicinal plants was studied by Babu and Manoharachary[37] and nineteen species of AM fungi were identified of which *Glomus* species were found to be more dominant than others. Distribution of AM fungi in the rhizosphere soil of betel vine was investigated and *Glomus* species were found more dominant followed by *Acaulospora* species[38]. Biodiversity of AM fungi in some liverworts[39], mangroves[40], pteridophytes[41] and bryophytes[42 & 43] has been well recognized.

Communities of arubuscular mycorrhizal fungi in the rhizosphere of *Caragana korshinkii* and *Hippophae rahmnoides* was studied by Zhang[44]. Singh *et al.*[45] studied the species diversity of AM fungi in jhum fallow and natural forest soils of Arunachal Pradesh, North Eastern India and reported forty four AMF species belonging to six genera. Diversity and distribution of AM fungi in different plants were also studied in Africa[46], Argentina[47], Australia[48], Bangladesh[49], Brazil[50 & 51], China[52, 53 & 54], Iran[55], Japan[56] and Nepal[57].

AM FUNGAL SPORULATION AND COLONIZATION: Arbuscular mycorrhizal diversity and richness is measured in terms of extent of root colonization and spore density. The quantitative and qualitative composition of spore population of AM fungi results from the complex fungus, plant and habitat interactions. Katdare and Bagool[58] surveyed some wild plants in Western Ghat and found seventy percent of plants exhibited association with AM fungi. Similarly, Hasan and Khan[59] while worked on mango in six district of Uttar Pradesh reported greater AM root colonization and sporulation at nursury conditions than orchads. Srinivas *et al.*[60] while analyzed the coal mine soil of Godavari basin, noticed a significant increase in spore population and decrease in percentage root colonization.

One of the important factors which may influence the assessment of species composition and richness is the depth of sampling. An *et al.*[61] recommended more than 15cm. deep surface is necessary to assess soil sample as some species have been found more abundant deeper in the soil. The occurrence of AMF at four soil depths i.e. 8, 15, 23 and 30cm. were studied by Prasad[62] and registered more species at 15cm. depth. Charles *et al.*[63] examined the different soils of Kanyakumari district and observed that spore abundance and diversity of AMF varied with location and soil types. According to Hart and Reader[64], Gigasporinae isolates were significantly less affected than Glominae isolates by soil disturbances in terms of root colonization and spore densities. Narolia *et al.*[65] studied the AM fungi association with *Pennisetum glaucum* and *Sorghum bicolor* and recognized the genus *Glomus* to be more dominant in rhizospheric soil of these two plants. Occurrence of AM fungi with sweet potato was also studied[66].

Onguene and Kuyper[67] reported the variation in AM colonization in different plant species from the rain forest of South Cameron. The variation in root colonization may be due to the exudation of toxic metabolites resulting in substances in proximity to the roots which attracts the AM fungi such as production of easily oxidizable compounds resulting in increased colonization[68 & 69]. The variation in percent root colonization has been reported to be affected by seasonal sporulation and seasonal variation in development of host plants[70]. This variation may also be the result of variable host susceptibility[71], diverse type of AM fungi in the rhizosphere soils of individual plant species, host efficiency in soil resource capture and utilization[72 & 73], soil types and quality[74]. Zangaro *et al.*[75] reported that the presence of fine root system as found in most of the investigated plant species possibly facilitates higher AM fungal colonization. Within the same genus, different species showed variation in root colonization due to different nutrient requirements of the host plant[76]. Thapar *et al.*[77] recorded varying degree of infection among different plants within a family.

A wide range of variation in spore population in the rhizosphere soils occurs which could due to the host species that apparently had direct effects on spore density and colonization of AM fungi[78]. The features favoring the higher population may either be the conductive to edaphic conditions for sporulation like low nutrient status, high aeration and optimum moisture or the undisturbed conditions of the soils which allowed sufficient time for the buildup of mycorrhizal spores[79]. Spore population is affected by a wide range of soil, climatic, fungal and host factors[80 & 81]. Moreira- Souza *et al.*[82] also reported higher spore population in their study. Patterns of spore production, spore quantity etc. are closely related to the plant phenology, root phenology and root production[83]. Every life history of a mycorrhizal fungus is subjected to the influence by plant roots. Spore germination, germination rate, direction of germ tubes, hyphal branching and recognition of the host root, penetration establishment, and intensity of colonization, growth of hyphae into soils and sporulation of the AM fungi were reported to be affected by the plant roots[84]. Different types of organic chemicals, volatile compounds were produced by the roots of different plants that could contribute to the activity and affect the life cycles of the AM fungi in the natural ecosystems. Bever *et al.*[85] and Bever[86] reported positive or negative feedback of the host species on the sporulation of different AM fungi i.e. some AMF species produced more spores on a certain host plant, although others did not sporulate or did so very sparingly. Hence, the composition of the AMF community will be defined by the host plant, which may indirectly interfere with the coexistence or not of other plant species. The study of Kumar and Ghosh[87] also indicates the host plant apparently had direct effects on spore density and frequency of mycorrhizal colonization in the roots.

Manoharachary *et al*.[88] screened thirty five AM fungi associated with sixteen medicinal and aromatic plants belonging to family apocyanaceae and reported *Glomus* to be most dominant genera represented by twenty one species followed by *Acaulospora* with seven species. The involvement of intercellular or intracellular mycorrhizal associations or association of more than one mycorrhizal fungus with single host plant species might be attributed to their physiological, ecological and genetical variability[89]. The sporulation pattern of *Glomus* might bring about the dominance of the taxon. Spores of *Glomus* are grown in cluster and sporulate more frequently than others. Twenty three species of AM fungi, which belong to genus *Glomus* were reported from some medicinal plants of Himachal Pradesh[23]. The soil and plant types were found to be more or less important factors contributing to such an existence of *Glomus*. Wang *et al.*[52] has reported the species of *Glomus* are the most widespread and abundant, followed by *Acaulospora* in agricultural soils of Sichuan Province of mainland China. More species of *Glomus* than that of *Acaulospora* was recognized by Zhang *et al*.[90] while they worked on various natural ecosystems. Spore density and species richness positively correlated with soil organic carbon and soil pH[46]. ZhangYong *et al*.[91] also found the wide occurrence of *Glomus* than *Acaulospora* on the northern slopes of the Tianshan mountains. A significant attempt was also made in order to evaluate the potential of different AM fungi on some growth and physiological parameters of medicinal plants[92 & 93].

CONCLUSION: Much of the information presented in our work elucidates patterns of mycorrhizal occurrence and distribution. Agricultural sustainability could be viewed as 'maximum plant production with minimum soil loss'. The management of their population in the soil is an essential tool for overall plant health in the present scenario of sustainable crop productivity. More studies are being emphasized to select the suitable indigenous AM fungal strains for the establishment and management of natural ecosystem and to make the people conscious about the role of mycorrhiza as an environmental friendly approach.

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