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ORIGINAL ARTICLE

Distribution of Arbuscular mycorrhizal fungi in Pench forest reserve, (Maharashtra), India

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ABSTRACT

The intense exploitation of natural forests in the subhumid to arid tropics is leading to degradation of stable ecosystems. The resulting changes in abiotic and biotic soil properties make the re-establishment of vegetation difficult. The beneficial effects of mycorrhizal fungi on growth and establishment of tree seedlings in such stressed environments is of paramount importance. The Arbuscular Mycorrhizal Fungi (AMF) are included in the phylum Glomeromycota which form symbiotic associations with plant roots and improve plant nutrition, growth and survival. In view of the importance of AM fungi to improve water utilization when water supply is inadequate, growth and survival of trees especially in degraded wastelands may be crucial to reforestation and reclamation efforts. The present paper explores the possibility of using mycorrhizal technology as an ecofriendly and cost effective technique to remove all constraints associated with reclamation of arid and wastelands. Undisturbed forest site of Nagpur viz. Pench forest was selected and mycorrhizal association in naturally occurring trees was studied for a period of two years. Physico-chemical analysis of rhizosphere soil was also done. Wide range of diversity and variation in spore density was recorded. All the plants were mycorrhizal. However, percent colonization in roots and number of spores in rhizosphere soil varied depending on host. Among the AM genus, Glomus was dominant .The study will be of great help in undertaking the future research on various aspects of AM fungi in Nagpur district.

Keywords: Pench, AM fungi, Wastelands, reclamation, trees, phytoremediation

1. INTRODUCTION

Arid regions comprise approximately one-fifth of the earth's land area and contain a large fraction of the known energy and mineral reserves. Restoration of lands devastated for resource extraction is an immediate priority and a challenging task for arid land ecologists. India has wide tracts of arid, semiarid and wastelands. These areas are devoid of any vegetational cover due to soil infertility and water stress. Forests are being denuded at very fast rate in our country and meanwhile human population also growing at an alarming rate. Productivity of land has also decrease due to constant use of chemical fertilizers. To increase productivity, it is necessary to increase the covered area and the efforts should be made to utilize the waste and barren lands. There is an urgent need to reforest these denuded areas. During last few years, there has been growing awareness of importance of Arbuscular Mycorrhizal (AM) fungi in improving plant growth and yield especially in stressed habitats [1]. AM fungi are important members of soil microbial community and can potentially offer benefits to low input and sustainable agroecosystem. Arbuscular mycorrhizas are symbiotic association between fungi belonging to phylum Glomeromycota [2] and the plant roots .They are the main component of the soil microbiota in most of the forest ecosystem. [3] The plant provides the fungus with organic carbon which has been estimated to represent about 20% of photoassimilates [4]. These associations represent a key factor in the below ground dynamics which influence species diversity and plant community structure. Advantages conferred on plants by AM fungi are enormous including increased nutrient uptake especially Phosphorus and hence plant growth, productivity and biomass [5]. Their extrametrical hyphae increase absorption of relatively immobile elements in soil such as Cu, Zn, K, Mg and certain other essential trace elements beyond root –hair zone. Mycorrhizal plants are also able to cope better than non-mycorrhizal plants with many adverse soil conditions including high salinity, extreme variations in soil pH, high temperature, drought, toxic heavy metals, soil pollutants and other environment stresses. Mycorrhizal plants show better performance during transplantation shocks. They also provide effective protection against root pathogens and hence decrease disease incidence [6]. Mycorrhizal plants show better performance during transplantation shocks. Suppressed uptakes of heavy metals in a few mycorrhizal plants have been reported thereby protecting the plant from toxic effects of high concentration of heavy metals. It also improves the plant water relations and provides protection to plant against soil toxins. The extramatrical hypha of Arbuscular mycorrhiza can improve soil structure by binding the soil particles into more stable aggregates. AM fungi hold tremendous potential for use in the reclamation of arid and semiarid lands where chief goal is maximum plant establishment with minimum inputs. These goals are shared by agriculture, forestry and horticulture. Plants introduced in disturbed arid lands face a variety of adverse conditions such as drought, low soil fertility, high temperature-stresses whose impacts on plant growth have been shown to be ameliorated in part by mycorrhizal associations. AM inocula offer viable biological alternatives to these costly inputs like fertilizers and irrigation costs. Inoculation of AM fungi would be highly beneficial in the reclamation of marginal soils, eroded, degraded or unstable habitats. Such soil situations are frequent in the tropics under both semi-arid and humid climates. Studies on occurrence and distribution of AMF flora in any forest ecosystem and their *in situ* maintenance is of prime importance in proper management of resources. Many factors such as dominant vegetation type, climate and edaphic properties influence the abundance and distribution of AMF in natural habit. AMF are recently reported to show low endemism [7] and their biogeography is largely determined by local environmental conditions. AMF have been reported to have declined due to farming practices such as mono-cropping and tillage etc. or excessive usage of chemical fertilizers and pesticides. Data available for natural ecosystems also supports the change in environment caused by heavy metal pollution, elevated CO_2 concentration, climate warming and invasive species affect the AMF community composition in the given area. Factors which contribute to environmental change such as loss of natural habitats, pollution, invasive species, anthropogenic activities and global warming are highlighted to be the main cause of global biodiversity loss. However considering the potential importance of these fungi in the recovery of disturbed lands and their possible use in land reclamation, research regarding AM fungi and their relationship to ecosystem recovery appears to be promising indeed [8, 9]. Before evaluating the significance

of mycorrhiza as a beneficial reforestation biotechnique, it is necessary to have some idea of the mycorrhizal status of the plant species occurring naturally in the undisturbed ecosystem. Selection of suitable fungal symbiont for reforestation varies in accordance with local site conditions, edaphic as well as climatic factors.

Despite the ubiquitous presence of AM fungi in most soils and colonization in most plant species, only limited information is available on mycorrhizal association in Nagpur. Before AM fungi can be utilized effectively in large scale forestation programs and sustainable agricultural systems, we need to understand their ecology and distribution in naturally occurring plants of the area. A systematic survey of the forest reserve of Nagpur was undertaken to assess the population dynamics and biodiversity of AM fungi in undisturbed soil and to study the intensity of AM association in the roots of the different trees growing in the area .In the present study an attempt has been made to determine the status of AM fungi in Nagpur District and explore the possibility of utilization of mycorrhizal technology as cost effective and ecofriendly approach towards sustainable development in Nagpur.

2. MATERIALS AND METHODS

Study Area:
It is located in Vidarbha region of Maharashtra State. The entire area is 257.26 Sq. Km. in the Pench National Park harbors variety of flora and fauna. Recently Govt. of Maharashtra has also notified the same area as area for Tiger Project. The region encompasses dense forests. Herbs are dominant followed by shrubs and trees. Flora is Xerophytic in nature. The forest type is Southern Tropical Dry Deciduous Forest. Moderate trees along with shrubs constitute chief woody components of the forest.

Selected Plant:
Following plants were selected from the site:
Dendrocalamus strictus (Roxb.) Nees., ***Tectona grandis*** L., ***Syzygium cumini*** (L.) Skeels, ***Ficus racemosa*** L., ***Butea monosperma*** (Lam.) Taub., ***Sterculia urens*** Roxb., ***Bombax ceiba*** L., ***Madhuca longifolia*** (Koen.) Mac. Bride **var.** ***latifolia*** (Roxb.) Chev. and ***Gardenia resinifera*** Roth.
On each sampling occasion, variation in air temperature and relative humidity was noted.

Soil Sampling:
Soil from rhizosphere of different trees growing under natural conditions was collected over a period of 2 years and was analyzed for Arbuscular Mycorrhizal spore counts. These soil samples were also used for analysis of soil ecological factors. The roots of the selected plants were also used for studying the colonization of the endophyte into the root tissue.

AM Fungal spore isolation:
AM Fungal spores were extracted using wet sieving and decanting technique [10]. Spores were counted under Stereozoom microscope. An average of 5 readings was taken. Different spores isolated from soil were also photographed to study spore taxonomy.

AM Fungi in roots:
Percent mycorrhizal colonization in roots- The cleaned roots were cut into 1cm long pieces and stained with Trypan Blue [11]. Minimum of 100 root segments were observed and colonization by AM fungi was calculated using the following formula:

$$\text{Percent root colonization (\%)} = \frac{\text{Total number of root segements colonized}}{\text{Total number of root segments studied}} \text{X100}$$

3. RESULTS AND DISCUSSION

Lot of diversity and variation in spore density was recorded at the site (**Table-1 & Fig-2**). All the plants showed mycorrhizal association (**Fig.-1**). Different structures formed by AM fungi *viz.* external hyphae, internal hyphae, vesicles and arbuscules were found to be associated with the roots of plant species (**Fig.-1**). The number of spore/ 10 grams of soil varied from 21 spores / 10 g soil (***Gardenia resinifera*** Roth.*)* to 185 spores / 10 g (***Sterculia urens*** Roxb.) (Table 1)

Percentage of root colonization varied from 9.09 % (***Butea monosperma*** (Lam.) Taub.) to ***Dendrocalamus strictus*** (Roxb.) Nees. (85.7%) *Glomus*, the most common genus of AM fungi was dominant. Plant species composition, soil and climatic conditions influence the abundance and diversity of AM spores in the area [12]. Spore production is also influenced by environmental condition together with

Table-1: Variation in AM fungal spores and percent colonization in different trees of Pench forest, Nagpur. (Naqvi)

Sr. No.	Name of the Plant	Family	Spores / 10g	% Roots Colonized	Hyphae	Vesicles	Arbuscules
01	***Dendrocalamus strictus*** (Roxb.) Nees.	Poaceae	40	85.7	+	+	+
02	***Tectona grandis*** L.	Verbenaceae	39	60	+	+	-
03	***Syzygium cumini*** (L.) Skeels	Myrtaceae	30	80.3	+	+	-
04	***Ficus racemosa*** L.	Moraceae	32	85	+	+	-
05	***Butea monosperma*** (Lam.) Taub.	Fabaceae	66	9.09	+	-	-
06	***Sterculia urens*** Roxb.	Strerculiaceae	185	79.3	+	+	+
07	***Bombax ceiba*** L.	Bombacaceae	72	66.6	+	-	-
08	***Madhuca longifolia*** (Koen.) Mac. Bride **var.** ***latifolia*** (Roxb.) Chev.	Sapotaceae	64	71.1	+	+	+
09	***Gardenia resinifera*** Roth.	Rubiaceae	21	13.3	+	+	+

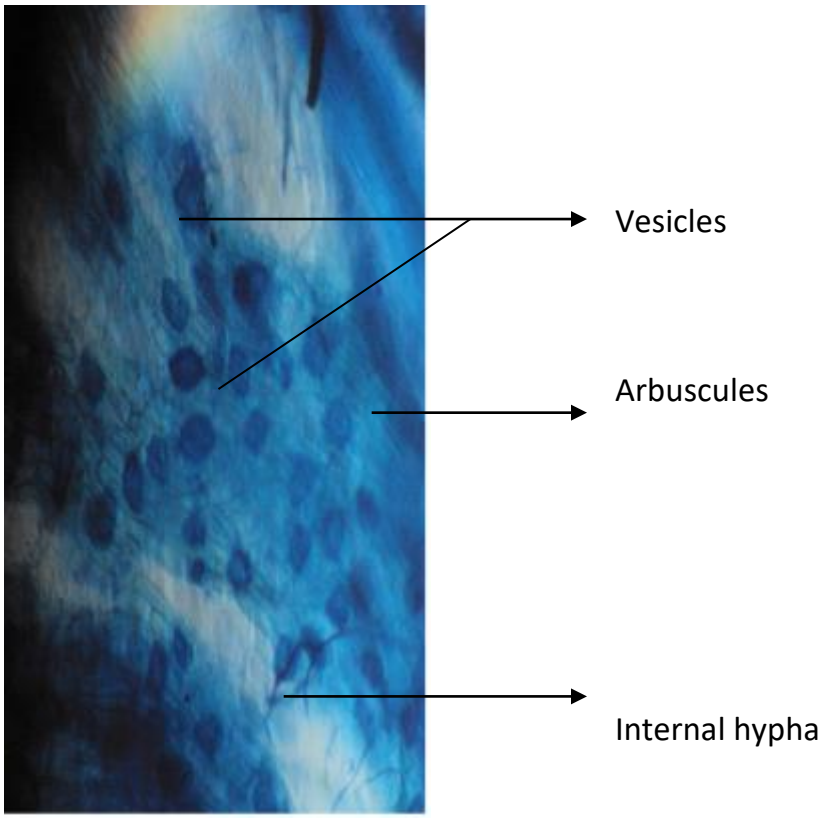

Figure-1: Endomycorrhizal colonization in plants of Pench forest, Nagpur (Naqvi)

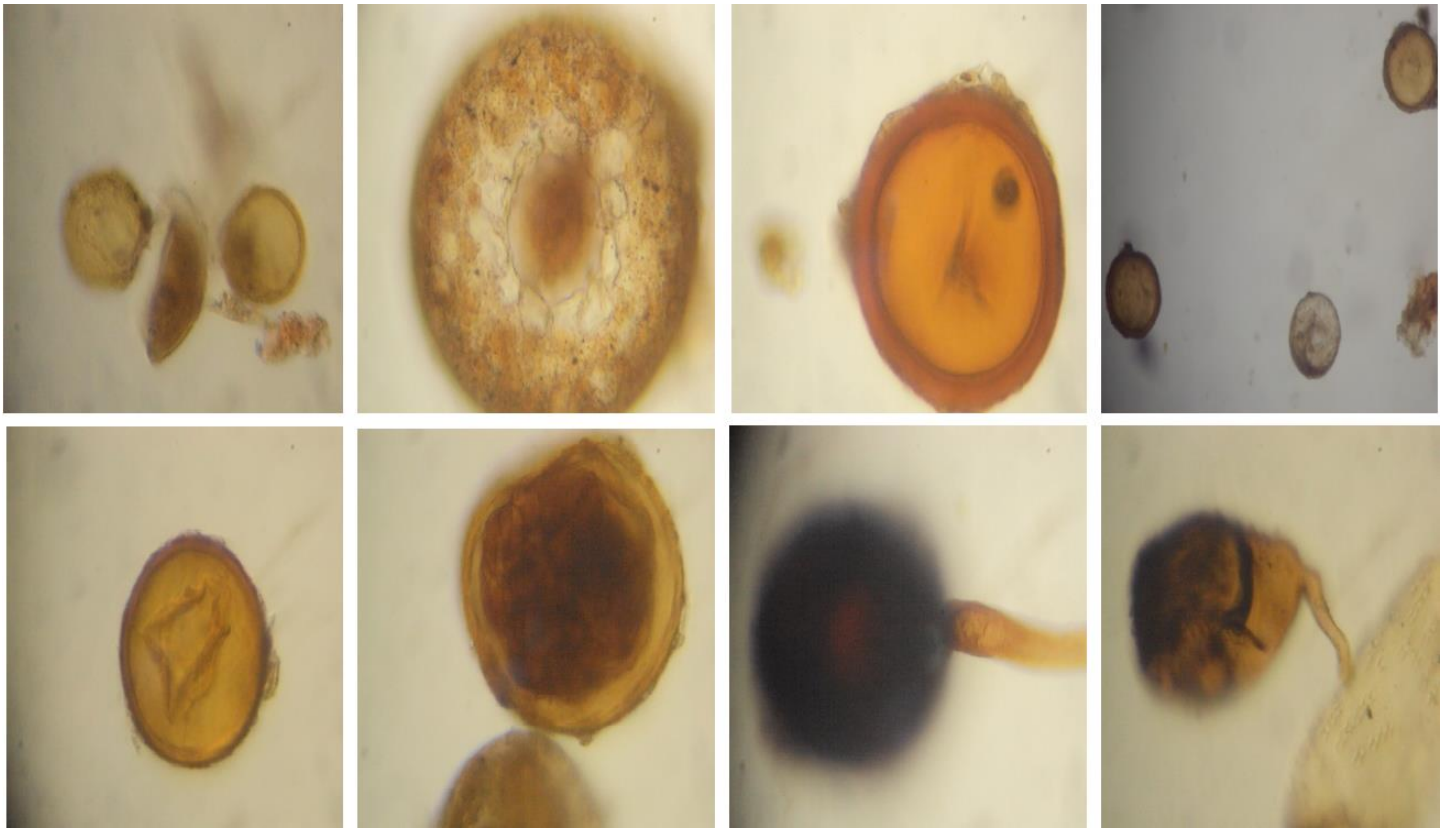

Figure-2: Mycorrhizal Spore Diversity in Pench Forest (Naqvi)

host species and soil type. It is now well established that AM fungi are sensitive to environmental conditions especially edaphic condition. Edaphic factors can affect spore germination, colonization of host root. In addition to the soil type and soil temperature, some other external factors like soil pH, nutrient levels affect the behavior of AM fungi. Soil phosphorus is another important abiotic parameter which affects AM spores. It has been shown that high level of soil P causes a decrease in spore population. Diversity and functioning of AMF communities have traditionally been based on root colonization estimation and AM spore count. AM spore population and root colonization pattern changes with seasonal variation and host plant phenology. Wide variation in percent colonization, density of AM fungal spores may be the result of variable host susceptibility, soil type, root morphology and mycorrhizal dependency of different host plants and other edapho-climatic factors [13] The AM fungal colonization and subsequent spore production depend on the type of host as well as on the duration of infection of these symbiotic organisms .Generally with increase in the growth period after infection, the host root colonization increase. The higher colonization in ***Dendrocalamus strictus*** (Roxb.) Nees. may be due to the effectiveness of AM fungal spores developed in root of this host. Highest percent of mycorrhizal infection in ***Dendrocalamus strictus*** (Roxb.) Nees. may also be attributed to the root exudates of these plants which might have stimulated the germination of mycorrhizal spores and increased the infection. Although these fungi are not host specific, host and fungal genotypes and soil abiotic as well as biotic variables have been shown to influence the nature of symbiosis. Climatic and edaphic factors can substantially influence AM association and its population. Variation in AM spore population, percentage of root infection and intensity of infection may be dependent on host plant, different soil factors [14]. The presence of hypha, vesicles, arbuscules are evidences of AM association. Generally, arbuscules die within 15 days of their formation and are therefore

sometimes not found in older roots. Vesicles are considered as storage organs produced in the older regions of roots. The lack of correlation between root colonization and spore number could be attributed to dormancy of AM spores

4. CONCLUSION

In view of the increased concern for environment quality, sustainable technology should be incorporated into afforestation programs. AM fungi are an important aspect of such an approach. A research program on mycorrhiza must embrace multidisciplinary approach and should include all aspects of plant growth including beneficial role of mycorrhizae and their possible manipulation to improve plant production. There could be two strategies for managing AM fungi in field. The first strategy is to develop inoculation techniques with efficient AM fungi adapted to the plant species and the environment. The second strategy is to manage the indigenous AM fungi by agricultural practices in such a way that efficient native fungi are enhanced and inefficient fungi are suppressed.

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Conflict of interest
No conflict of interest influenced in this research.

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