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Research Article

Effects of Soil Nutrient Status on Arbuscular Mycorrhizal Fungi Associated with Pteridophytes in Dharashiv District, Maharashtra, India

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Abstract

The present investigation evaluates the effects of soil nutrient status on AM fungi associated with four common pteridophytes—Equisetum hyemale, Marsilea quadrifolia, Nephrolepis exaltata, and Ophioglossum vulgatum—collected from different localities in and around Dharashiv District, Maharashtra, India. Sixteen physico-chemical parameters of rhizospheric soils, including pH, electrical conductivity, organic carbon, primary nutrients (N, P, K), secondary nutrients (Ca, Mg, S), and micronutrients (Na, Zn, Fe, Mn, Cu, B, and Mo), were analyzed. The results highlight notable variability in soil nutrient composition among pteridophyte rhizospheres, emphasizing the influence of edaphic factors on AM fungal associations and soil–plant–microbe interactions in semi-arid ecosystems.

INTRODUCTION:

Arbuscular mycorrhizal (AM) fungi constitute one of the most ancient and widespread symbiotic associations with vascular plants, playing a fundamental role in terrestrial ecosystem functioning. This mutualistic relationship enhances plant mineral nutrition, particularly the acquisition of poorly mobile nutrients such as phosphorus, zinc, and copper, while the host plant supplies photosynthetically derived carbon to the fungal partner. The extensive extra-radical hyphal network of AM fungi increases the effective absorptive surface area of roots, thereby improving nutrient uptake efficiency, water relations, and plant tolerance to both biotic and abiotic stresses (Smith and Read, 2008; Leake et al., 2004).

The establishment, diversity, and efficiency of AM fungal symbiosis are strongly governed by soil physico-chemical characteristics, including nutrient availability, pH, organic matter content, and soil texture. Alterations in soil nutrient status due to intensive agricultural practices, particularly the excessive application of chemical fertilizers, can adversely affect AM fungal colonization and community structure. Conversely, sustainable soil management practices favor the persistence and functional efficiency of AM fungi, thereby enhancing soil fertility and ecosystem stability. Due to their ecological plasticity, AM fungi are capable of surviving under a wide range of environmental conditions, including arid and semi-arid regions, and form a critical component of the soil–plant–microbial interface. Phosphorus limitation is a common feature of tropical and subtropical soils, especially in degraded and nutrient-depleted landscapes. Under such conditions, AM fungi play a pivotal role in facilitating phosphorus uptake and supporting plant establishment and growth (Smith et al., 2003).

Their significance extends to land reclamation and ecological restoration, where AM fungal inoculation has been shown to improve soil aggregation, nutrient cycling, and vegetation succession. Mycorrhizal associations thus contribute not only to individual plant performance but also to broader ecosystem resilience and sustainability.

In India, extensive research has documented the beneficial effects of AM fungi on crop productivity and soil health across varied agro-climatic zones, including Uttar Pradesh (Hasan, 2002), Karnataka (Shivaputra et al., 2004), West Bengal and Assam (Roy et al., 2002), Maharashtra (Borde et al., 2009; Bhale et al., 2011), Tamil Nadu (Muthukumar and Udaiyan, 2006), Goa (Khade and Rodrigues, 2009), and Delhi (Kapoor et al., 2004). However, despite growing interest in AM fungal research, studies focusing on non-seed vascular plants such as pteridophytes remain limited.

Pteridophytes occupy an important evolutionary position and commonly grow in diverse habitats, including nutrient-deficient soils where symbiotic associations are critical for survival. The interaction between soil nutrient status and AM fungal colonization in pteridophytes is therefore of considerable ecological significance.

The Marathwada region of Maharashtra, particularly Dharashiv District, is characterized by semi-arid climatic conditions, heterogeneous soil types, and increasing anthropogenic pressures that influence soil fertility and microbial dynamics. These conditions provide a suitable framework for examining the interaction between soil nutrient status and AM fungal associations in pteridophytes. In this context, the present study investigates the effects of soil nutrient status on arbuscular mycorrhizal fungi associated with selected pteridophytes from Dharashiv District, Maharashtra, India. By assessing key physico-chemical properties of rhizospheric soils, the study aims to elucidate the role of edaphic factors in shaping AM fungal associations and to generate baseline information that may support sustainable soil management and ecological restoration efforts in semi-arid ecosystems.

MATERIALS AND METHODS:

Composite rhizospheric soil of pteridophytes i.e. N. exaltata, M. quadrifolia, E. hyemale & O. vulgatum from Dharashiv District were collected & analyzed physico chemical parameters during 2024 to 2025. For air drying, rhizospheric soil was spread out on a tray. Over a 2 mm sieve, it was sieved and used for characterization of various 16 parameter soil analysis was done. By pH meter potentiometrically in a 1:5 soil – water suspension, pH of the soil was measured. Concentration of soluble salts in the soil provided by Electrical Conductivity (dS/m) was measured in 1:5 soil-water suspensions by conductivity meter. By oxidizing organic carbon with potassium dichromate and sulphuric acid, organic Carbon was evaluated by Walkely and Black (1934) method. By alkaline permanganate method by using Kjeldhal tube Subbiah and Asija (1956), By Olsens method by using spectrophotometer (Olsen et al, 1954) and Bray & Kurtz (1945), available nitrogen was assessed. Available Phosphorus in soil was also determined. By Ammonium acetate method of Hanway and Heidel (1952) using Flame photometer, water soluble and exchangeable Potassium was calculated. By EDTA titration (GOI, 2011) Calcium and Magnesium cations were estimated. By acid digestion of soil Jackson (1967), analysis of Ferrous, Mangenese, Copper and Zinc were done.

RESULT:

Soil texture determines water holding capacity, retention of nutrients and aeration of soil. Soil fertility refers to the amount of nutrients available to plants in the soil. Soil fertility varied from site to site and depends on microbiota. Chemical elements are known to be important for plant's growth and survival. In this investigation, sixteen physico-chemical parameters were analysed from 04 common ptridophytes i.e., Equisetum hyemale, Marsilea quadrifolia, Nephrolepis exaltata and Ophioglossum vulgatum of rhizospheric soil. The sixteen different physicochemical parameters of the above mentioned four common pteridophytes studied and analyzed are pH, Ele. Conductivity (mS), Organic carbon%, and various elements mentioned in the observation table.

Plants use primary macro nutrients like Nitrogen (N) found more in M. quadrifolia (370kg/ha) while less in O. vulgatum (125.44kg/ha), Phosphorus (P) found very low and Potassium (K) in large amounts. The secondary macro nutrients like Calcium (Ca), Magnesium (Mg), and Sulfur (S) are usually enough in soil. Sulfur is usually found in sufficient amounts. Micronutrients are essential for plant growth in only very small or trace quantities. Of the micronutrients, Manganese (Mn), Zinc (Zn) & Sulfur(S) is in sufficient, Sodium (Na), Boron (B) very less while Molybdenum (Mo) is in more amount (11.84 mg/kg) than standard. EC (mS) is sufficient while

Organic Carbon (OC %) found more in tested rhizospheric soil of pteridophytes. pH of soil samples of all four plants is mostly alkaline but found highly alkaline in N. exaltata than the remaining three plants. Ele. Conductivity (mS) found to be less. Organic carbon % is found is more in all the tested soil samples. Nitrogen (kg/ha) is found more in M. quadrifolia (370 kg / ha) while less in O. vulgatum (125.44 kg / ha) and E. hyemale (156.8 kg / ha). Phosphorus (kg / ha) was found very less in tested soil of pteridophyte. Potassium (kg / ha) was found very high in M. quadrifolia (1163.9 kg / ha) and less in other pteridophytic species. Calcium (m.Eq.) was found very less in O. vulgatum (2.63m.Eq.) and more in M. quadrifolia (6.82 m.Eq.). Magnesium (m.Eq.) was found slight balanced in tested soil of pteridophyte. Amoung the all four plants, it is found more in M. quadrifolia (17.93m.Eq.) and less in O. *vulgatum* (6.91m.Eq.). Sodium (m.Eq.) was found very poor in all the four plants. Zinc (ppm) was found balanced in tested soil of pteridophytes, it is found more in *N exaltata* (4.47ppm) and less in *O. vulgatum* (2.8ppm). Ferrous (ppm) was also found in balanced amount in tested soil of pteridophyte, it is more in *N. exaltata* (4.07ppm) and less in *O. vulgatum* (2.6ppm). Manganese (ppm) was found in balanced amount, it is more in *O. vulgatum* (4.21ppm) and less in *E. hyemale* (3.14ppm) Copper (ppm) was found more in *N. exaltata* (1.53ppm) and less in *O. vulgatum* (0.55ppm). Boron (mg/gm) was found very less in *M. quadrifolia* (16mg/gm), *O. vulgatum* (16mg/gm) *N. exaltata* (16mg/gm) and in balanced amount in *E. hyemale* (61mg/gm). Sulfur (mg/kg) was found in balanced amount in all the three plants except less in *M. quadrifolia* (7.69mg/kg). Molybdenum (mg/kg) was found very high in all the three plants except *M. quadrifolia* (1.08mg/kg).

DISCUSSION:

The mineral fraction of the soil provides support to plant roots by slowly releasing nutrients in the soil solution. In the soil Mineral nutrients are found and are absorbed through the plant's roots which are known to be important for plant growth. Large amount of primary macronutrients nutrients Nitrogen (N), Phosphorus (P), and Potassium (K) are used by plants for their growth and survival, hence farmers add them. Fertilization is not always needed as secondary macronutrients like Calcium (Ca), Magnesium (Mg) and Sulfur (S) are found enough in the soil. Trace elements or micronutrients such as Boron (B), Copper (Cu), Iron (Fe), Chloride (Cl), Manganese (Mn), Molybdenum (Mo) and Zinc (Zn) are needed in only very small (micro) quantities and are essential for plant growth. Ecological, economical and social functions of the region are affected by a natural resource soil where rural human life is agriculture dependent. Key functions are performed by sustainable farming activities depending on capacity of land and which is measure of economic status of population.

Table : **Soil analysis of four different Pteridophytes**

Sr. No	Parameter	Standard Range	Pteridophytes			
			Eh	*Mq*	*Ne*	*Ov*
1	pH	6.5 - 7.5	7.3	7.27	7.78	7.2
2	Ele. conductivity (mS)	>1.0	0.1	0.14	0.1	0.12
3	Organic carbon%	0.41 - 0.60	4.67	5.93	5.39	3.56
4	Nitrogen (kg/ha)	161 - 320	156.8	370	313	125.44
5	Phosphorus (kg/ ha)	31 - 50	26.81	13.78	19.15	4.59
6	Potassium (kg / ha)	181 - 240	628.9	1163.9	241.9	294.3
7	Calcium (m. Eq.)	65 - 80	3.83	6.82	4.19	2.63
8	Magnesium (m. Eq.)	10 - 15	10.08	17.93	11.02	6.91
9	Sodium (m. Eq.)	5 - 15	0.3	0.38	0.97	0.1
10	Zinc (ppm)	1.0 - 5.0	4.09	3.64	4.47	2.8
11	Ferrous (ppm)	2.5 - 5.0	4.3	3.9	4.07	2.6
12	Manganese (ppm)	2.0 - 5.0	3.14	4.7	3.71	4.21
13	Copper (ppm)	0.2 - 0.5	0.56	1.03	1.53	0.55
14	Boron (mg/gm)	30 - 100	61	16	16	16
15	Sulfur (mg/kg)	10 - 20	13	7.69	14.96	12.69
16	Molybdenum (mg/kg)	0.8 - 3.3	7.17	1.08	6.78	11.84

Legends: *Mq*- *Marsilea quadrifolia*, *Ov*- *Ophioglossum vulgatum*, Ne- *Nephrolepis exaltata*, and *Eh*- *Equisetum hyemale*.

Pujar et al. (2012) on observing the pH ranged 7.9 to 8.4 samples of soil having slightly above the optimum range (5.5-8.00) considered to be satisfactory for horticulture crops. Electrical conductivity (dS/m) of wheat cultivars (115) than control (120) was decreased by the treatment of sunflower leaves extract on wheat cultivars (Margalla 99) and pH in control (6.5) lower and increased in treatment (6.7) was observed by Kamal and Bano (2008).

Bhat (2011) observed higher P- availability in site 1, 51.80 and in site 2 it is 43.90 mg/kg under different agro ecological conditions. Velmurugan et al. (2012) observed that phosphorous content was higher in T2 (chemical fertilizer, 144.322±0.209) and T3 (Manure e, 147.218±0.089) of sunflower (Co-4) and lower in the treatments of T1 (control, 92.237±0.292) in red soil. Agricultural productivity is promoted by good quality agricultural soil and to fulfill the requirements sustains physical chemical and biological attributes (Reynolds et al., 2007).

By increasing ‘C’ input in soil, AMF have the potential to improve physical, chemical and biological quality of soil (Rillig et al., 2001) and formation and maintenance of soil structure (Rillig and Mummey, 2006). For binding soil components, organic matter acts as adhesive improving water infiltration and water holding capacity. The indicator of soil quality and productivity is organic carbon or organic matter (Fawcett and Caruana, 2001).

The relation between soil characters and occurrence of AMF was studied by Sreevani and Reddy (2004) where alkaline soils (pH higher than 8.0) have not favoured mycorrhizal fungi where as greater number of AM fungal propagules were found in neutral to slightly alkaline (pH 7 to 8) soil. Greater number of AM fungal propagules had been in nutritionally deficient soils (zinc, copper, nitrogen, phosphorus and potassium) whereas the population of AM fungi was inhibited by high levels of these nutrients. The regression coefficient value for spore density vs. Phosphorus was 0.957; vs. Nitrogen was 0.938 and vs. Potassium was 0.993. It was 0.948, 0.985, 0.979 and 0.973 for micronutrients Zn, Cu, Mn & Fe respectively.

Vyas and Vyas (2012) supported results observed during investigation where spore density of AMF had a negative correlation with Olsen's P content of the soil and a strong positive correlation with soil pH and organic carbon content. In various stages of decomposition, soil structure and tilth depends on organic matter in the soil which includes residues of plants and animal origin, soil organisms and their synthesized by-products. The spore densities of AMF, weak and negative correlation had been with electrical conductivity, in turkey. Significantly and positively CaCO3 percentages (r = 0.644) were correlated whereas to the soil organic matter, N, P, K, Ca, Na, Cu and B, it was negatively related. With infection rate (colonization) (r = 0.65, 0.732 and 0.686 respectively), soil Mg, Cu and Zn content had positive correlation. But, with EC, P and Na contents of soil, negative and non significant correlation between infection rates (Karaarslan and Uyanöz, 2011).

MAU (2012) assessed Physico - Chemical properties of Marathwada soil showed, Mn (1.20 to 27.20) ppm, Cu (0.78 to 4.30 ppm), Fe (0.6 to 16.00 ppm), Ca (- 0.00 to 22.0 %), N(less to medium), P (less to medium), K (medium to more), Zn (0.1 to 3.06 ppm), Organic carbon (– 0.30 to 0.80 %), pH (7.0 to 8.5) and salinity EC (0.1 to 0.35 dS/m). Our results showed resemblance with Colour of the soil in region; as the colour is dark yellow, brown, and white to brownish black. In this investigation, sixteen physico- chemical parameters were analysed from 04 comman pteridophytes and organic carbon (OC) found more.

Conclusion:

The present study concludes that soil physico-chemical properties significantly influence nutrient availability and soil fertility in the rhizosphere of pteridophytic plants. Analysis of sixteen soil parameters revealed notable interspecific variation among *Equisetum hyemale, Marsilea quadrifolia, Nephrolepis exaltata,* and *Ophioglossum vulgatum.* The soils were predominantly alkaline with adequate electrical conductivity and high organic carbon content, indicating favorable conditions for microbial activity. Nitrogen availability varied widely, phosphorus was consistently deficient, and potassium occurred in excess, while secondary nutrients were generally sufficient. Most micronutrients were present in balanced amounts, except for boron deficiency and elevated molybdenum levels. Overall, the study highlights the importance of soil nutrient dynamics in shaping pteridophyte rhizospheres and provides baseline data for understanding soil–plant interactions in the Dharashiv region of Maharashtra.

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