A CASE STUDY:

Mycorrhizal spore density in relation to land use and soil depth in a village landscape of Garhwal Himalaya, India

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SUMMARY

The present study was aimed to investigate the effect of land use and soil depth on mycorrhizal spores in village landscape of Garhwal Himalaya, India. The study showed that total spore abundance decreased with depth in all land use types and showed interaction of land use and soil depth. Since majority of AM fungi produce soil-borne spores and spore count is advantageous for evaluating the effect of land use and soil depth. The effect of depth was more marked in more intensively ploughed homegardens and irrigated agricultural land use compared to less intensively tilled rainfed agriculture. The differences between land uses were more marked in spore abundance in relation to soil depth. Spore density was correlated with root biomass. Further studies are needed to understand the effect of season and management of the respective land uses.

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Key Words :
Mycorrhizal spores, Land use, Soil depth, Soil organic carbon, Root biomass

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Mycorrhizal association between plants a AM fungal communities are influenced by land use (Oehl *et al.*, 2003; Sturmer and Siqueira, 2011), soil depth (Cardoson *et al.*, 2003; Choudhary *et al.*, 2010) and by plant species composition, soil properties, climatic conditions and management practices such as fire, tillage, crop rotation and fallowing (Rashid *et al.,* 1997; Muthukumar and Udaiyan, 2002; Lovelock *et al.,* 2003; Martinez and Johnson, 2010). Natural ecosystems dominated by perennial trees and shrubs, spores had fewer compared to the adjacent agricultural soils, but some virgin grasslands showed higher spore numbers than the adjacent wheat crop field. In some environments, cultivation (tillage and fertilizer application) reduces VAM diversity, while in others it enhances the VAM diversity (Abbott and Robson, 1991).Vertebrates and invertebrates act as potential vectors of VAM. Earthworms concentrate VAM propogules in their casts. Thus, agricultural soil management can greatly influence the population size and activity of both VAM fungi and earthworms (Lee *et al.,* 1996).

The diversity of organisms involved in nutrient cycling may be substantially reduced under agricultural intensification. Land use distribution is unique in Garhwal Himalaya with heterogeneity in the landscape occupying three dimensional space in contrast to two dimensional spatiality on low lands. The variation axists in the distribution of biological diversity between the land uses which are primarily imparting soil fertility of the land uses. The objective of this paper is to see the effect of land use and soil depth on mycorrhizal spores in a village landscape of Garhwal Himalaya.

EXPERIMENTAL METHODOLOGY

Study area:

The Garhwal Himalaya, spread over a geographical area of 29698 km2 comprises five districts of Uttarakhand state of India *viz.,* Uttarkashi, Chamoli, Pauri, Tehri and Dehradun. The study was carried out in and around the Chamali village landscape in Chamoli district (30º 27[1] N latitude and 79º 5[1] E longitude). The landscape covers an elevation range of 800-1400 m above mean sea level (amsl). The year consists of three seasons: dry summer season (April-June), warm rainy season (July-September), and winter season (October-March). Annual average rainfall is about 1200 mm and about 80 per cent of total rainfall is received during rainy season. The parent material is represented by feldspathic quartz schists, quartz muscovite schists and quartz chlorite schists, and can be classified as Dystric cambisol according to FAO soil classification system. The village landscape is differentiated into seven land use-land cover types: (a) OF- Oak (*Quercus leucotrichophora*) forest, (b) PF - Pine (*Pinus roxburghii*) forest, (c) Home garden, (d) IA - Irrigated agricultural land, (e) RA - Rain-fed agricultural land, (f) AA - Abandoned agricultural land and (g) SL - Scrub land.

AM spores:

Soil sampling was carried out in the month of June 2005 and AM fungal spores extracted following wet-sieving and then separated from organic matter by centrifugation and counted the number of spores in the sample (Abbott and Robson, 1991).

EXPERIMENTAL FINDINGS AND DISCUSSION

Majority of AM fungi produce soil-borne spores. The spores of AMF could be viewed as a surrogate or indicator of mycorrhizal incidence as spore numbers and root colonization have been found to be positively correlated (Fischer *et al*., 1994; Onguene, 2000), sporulation is positively correlated with the growth of mycorrhizal plants (Hetrick and Bloom, 1986; Giovannetti *et al*., 1988) and the factors that stimulate or inhibit sporulation, inhibit colonization as well (Daft and Nicolson, 1972). Spore count for evaluating diversity and abundance of mycorrhizae is advantageous in that spores are highly resistant to adverse conditions (Abbot and Robson, 1991) and spore community is likely to reflect the previous history of a mycorrhizal symbiosis (Harley and Smith, 1983). Total spore abundance decreased with depth in all land use types except scrub land where no change or a marginal increase was observed in the surface layers, however declined for the subsequent layers. There was a significant interaction of land use and soil depth (Table 1). Pine forest had the highest number of spores in 0-10 cm soil layer and abandoned agriculture land had least number of spores (Fig. 1).

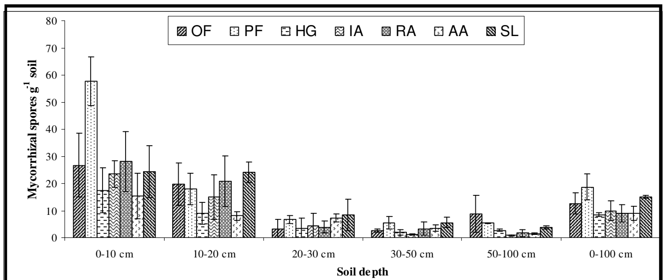

Fig. 1 : Mycorrhizal spore distribution in different land uses from various soil depths in a village landscape of Garhwal Himalaya

Mycorrhizal spores might have highly associated with pine roots compared to oak and other plants in this study, however, we have not confirmed in this study due to certain constraints. Further, spore count has an advantage over the MPN method in that assumptions concerning host specificity of VAM are not made, *i.e.,* that trap plants might fail to reveal presence of many species as spores. Exceptions to this general trend do exist (Moutoglis and Widden, 1996). In the present situation, it appears that there are significant effects of season, management practices and their interactions.

The differences between land uses were more marked in spore abundance in relation to soil depth in this study, however, these was no effect of season (Guadarama and Alvarez-Sanchez, 1999) and differences between control and burnt sites (Rashid *et al*., 1997). However, Guadarrama and Alvarez-Sanchez (1999) concluded that higher species richness as well as abundance of spores are likely in dry season as also observed by Janos *et al*. (1995) and is due to decrease of spore germination in rainy season (Mason *et al*., 1992; Ragupathy and Mahadevan, 1993).

Most of the studies on mycorrhiza in the tropics and sub-tropical region have concentrated on top 0-20 cm soil, though AMF at deeper depths may be equally important where trees have roots reaching the deeper soil layers. The present study showed higher number of

Table 1 : Effect of land use and soil depth on mycorhizal spore density following two-way analysis of variance

Source of variation	SS	df	MS	F	P-value	F crit
Soil depth	10439	5	2088	79.85	1.97E-30	2.32
Land uses	1210	6	202	7.71	1.29E-06	2.21
Soil depth and land use interaction	3228	30	108	4.11	1.68E-07	1.59
Within land uses	2196	84	26			
Total	17073	125				

spores and root biomass in surface layers compared to deeper layers (Fig. 2). Muthukumar *et al*. (2003) observed that root density, AM colonization and AM fungal spore numbers decreased with soil depth in all forests in Xishuangbanna, southwest China and similar observation was made by Douds *et al*.(1995). Jacobsen and Nielsen (1983) did not observe any change upto 20 cm depth, and Ananth and Rickeri (1991) found the highest concentration in 30-45 cm soil layer.

An *et al*. (1990) found some species in a soybean field more prevalent at 0-15 cm depth and others at 30-45 cm depth. Surface soil had higher spore abundance in no-tilled agricultural system and tilled soil had higher abundance in deeper soils (Abbott and Robson, 1991). Douds *et al*. (1995) observed that distributions of spores of VAM fungi with depth were affected by sampling date, tillage and farming system type. Cardoson *et al*. (2003) observed that agro-forestry system had greater numbers of AMF spores and as well as roots in deeper layers (40-60 cm) and lower values in the upper layers (0-7.5 cm) compared to unshaded coffee system. In the present study also, the effect of depth was more marked in more intensively ploughed homegardens and irrigated agricultural land use compared to less intensively tilled rainfed agriculture.

Spore populations have been found to decrease with increasing clay content, increase with increasing pH and

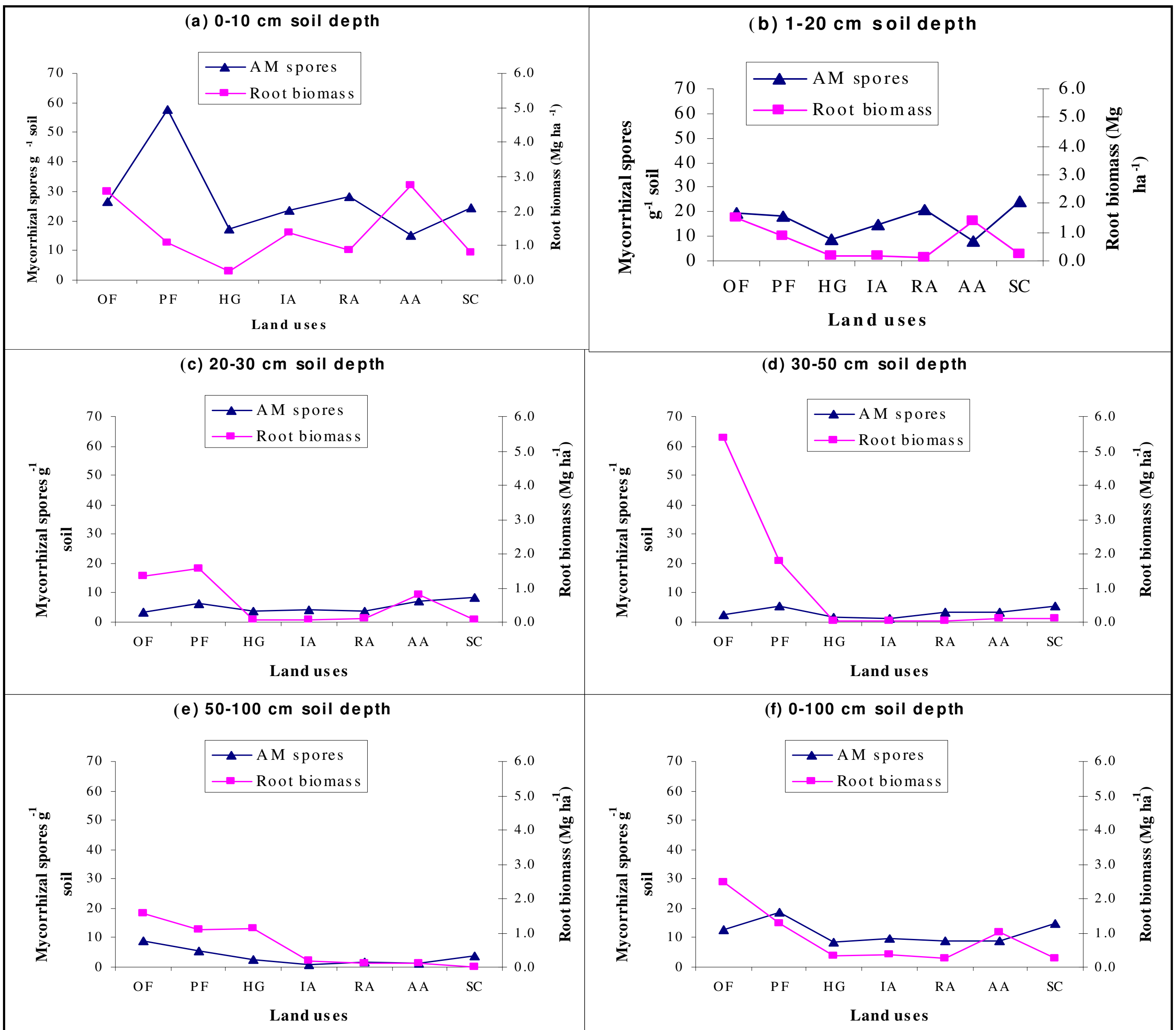

Fig. 2 : Distribution of mycorrhizal spores and root biomass in different land uses at different soil depths

carbon, and decrease with increasing soil phosphorus (Day *et al*., 1987).Organic carbon decreased with increase in soil depth in all the land uses as observed in this study and similar trend was also observed for mycorrhizal spores indicating the influence of AM fungi over soil fertility (Fig. 3).

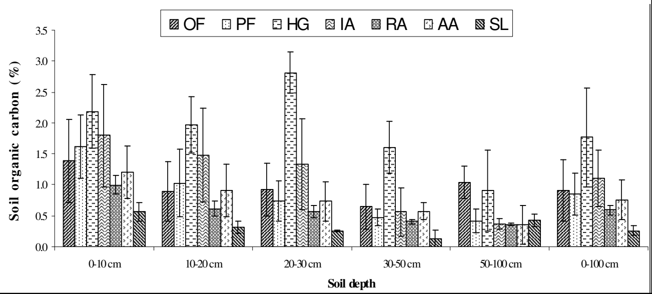

Fig. 3 : Soil organic carbon in different land uses at different soil depths

McGee *et al*. (1997) while working on soils in eastern Australia used to grow cotton, considered a density of 4 to 212 spores g^{-1} soil to be high, and assumed that 5 spores g^{-1} soil would be required to initiate maximum levels of colonization taking spore germination rate as 5 per cent. Bagyaraj *et al*. (1989) added 12500 infective propogules to each test plant grown in 4 kg soil. If these conclusions are applied to the present study area, soil seems not to be very deficient in spore abundance. However, wheather infective propogules of the most advantageous mycorrhiza are present in sufficient numbers and the soil physico-chemical characteristics are favourable for function of such mycorrhizal association are the aspects which need to be further investigated.

Conclusion:

Mycorrhizal spore density is influenced by soil depth and land use. Spore density decreased with increase in soil depth and found highest numbers at surface soils compared to deeper layers. Highest spore density occurred in pine forest, oak forest and scrub land compared to agricultural lands. Mycorrhizal spores vary with land uses depending on the management practices within the land uses and the crops grown in agricultural field. Further studies are needed to understand the effect of season and management of the respective land uses.

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