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Effect of Land Use Change on Status of Arbuscular Mycorrhizal Fungi in Some Hyrcanian Forest Soil A Case Study of Lahidjan Region, Iran

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This study was conducted to assess the effects of land use change on status of arbuscular mycorrhizal fungi in the some Hyrnaian forest soils of Guilan province in north of Iran. Soil samples were collected on 5 adjacent plots, which belong to 3 land-use types including native broadleaf forest, 13-y old *Pinus taeda* and Poplar plantation. Some soil properties, spore population and root colonization of *Arbuscular mycorrhiza* fungi have been measured. The mean spore numbers was found to fluctuate from 23 to 36.8 20 g^{-1} in *Pinus taeda* and native forest soils, respectively. Significant difference found in *Arbuscular mycorrhiza* fungi spore number among land use types. Two afforested soil with *Pinus taeda* and *Populus* sp had lower *Arbuscular mycorrhiza* fungi spore number than native broadleaf forest soil. Statistically significant variations were observed in the total percentage of mycorrhizal colonization among the roots of different tree species. The highest percentage of colonization found among the tree roots of native forest. It may be concluded that soil management system and plant cover are the factors affecting *Arbuscular mycorrhiza* fungistatus in some Hyrcanian forest soils and show that it may be useful as an indicator of land use change effects on Hyrcanian forest soil.

Key Words: Land use, *Arbuscular mycorrhiza*, Spore, Colonization.

INTRODUCTION

Arbuscular mycorrhizal fungi (AMF) are ubiquitous symbionts in terrestrial ecosystems, colonizing a majority of land plants[1]. *Arbuscular mycorrhiza* fungi association is the most ancient and probably aided the first terrestrial plants to colonize by scavenging for phosphate[2]. This association is much more important in desert ecosystems and may play a significant role in plant establishment and growth by bridging between plant and soil[3].

The environment of soil organisms in managed ecosystems can be influenced by any combination of land use factors, such as tillage, pesticide and fertilizer

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application, soil compaction during harvest and removal plant biomass[4]. The conversion of natural forests into industrial forest plantations, subsistence or cash crops brings changes in which plant species, soil organic matter, soil nutrients, soil structure and soil fungi may be affected[5]. The site is usually cleared of multi-species and normally planted with a single species of one age-class. This constitutes a drastic site disturbance which alters mycorrhizal abundance and species composition in the site. Jasper *et al.*[6] observed a drop in spore numbers and a shift in species composition after disturbance of some Australian sites.

Also the dependence of the abundance of *Arbuscular mycorrhiza* fungi and their spores on physical characteristics of soil reported by Ortega-Larrocca *et al.*[7]. Most of studies have focussed on the interactions between soil microorganisms and a single *Arbuscular mycorrhiza* fungi added to microcosm units. Such studies are a first approximation to understanding the complex interactions that can occur, using controlled conditions that would be impossible in the field. However, the ecology of *Arbuscular mycorrhiza* fungi in the field may be quite different. It certainly is more complex, with diversity of *Arbuscular mycorrhiza* fungi in the root systems of plants. It is evident that a wide range of associations of soil constituents with *Arbuscular mycorrhiza* fungi may occur in soils and presumably affect the mycorrhizal symbiosis with plants[8]. Nevertheless there is relatively limited information about effect of land use change on the status of *Arbuscular mycorrhiza* fungi in Hyrcanian forest soils. Thus, the objective of this studies is to study the effect of land use change on the *Arbuscular mycorrhiza* fungi populations in some Hyrcanian forest soil, northern Iran.

EXPERIMENTAL

The site chosen for this study are in Guilan province, the northern of Iran with different land use/cover systems. They are located above 80-150 m above sea level at 37º, 08′ N, 50º 02′ E to 37º 12′ N, 50º 02′ E. The mean annual temperature is 18 ºC and mean annual precipitation 1850 mm at the sites. The areas sampled included a native broadleaf forest dominated by ironwood (*Parrotia persica*) and *Carpinus* sp. that was never cleared or plowed and two afforested sites with loblolly pine (*Pinus taeda*) and poplar (*Populus* sp.).

Soils were sampled in 5 replicate (plots) of each land-use/cover type. Five samples in each replicate were composite for each forest. Air-dry soil was sieved to pass a 2 mm mesh screen, for particle size analysis using the hydrometer method[9]. Soil pH was measured[10] in a 1:2.5 soil: $CaCl_2$ 0.01M extract after shaking for 0.5 h. Organic carbon was analyzed[11] by dichromate oxidation and titration with ferrous ammonium sulfate. Exchangeable cations (K^+, Ca^{2+}+Mg^{2+}) were measured according to Bower *et al.*[12]. Available phosphorus was extracted with 0.5 M $NaHCO_3$ (pH = 8.5) and determined spectrophotometrically[13]. Spores of *Arbuscular mycorrhiza* fungi was isolated from 20 g sub-samples by wet sieving[14] and sucrose gradient centrifugation[15], the counting was done under a stereoscopic microscope. Data statistically analyzed by ANOVA (SAS, Institute) to test the effect of treatments. Turkey multiple range tests were made to assess the land use effects on the abundance of *Arbuscular mycorrhiza* fungi populations in soils.

RESULTS AND DISCUSSION

Soil pH values range from 5.65 to 6.48. The mean pH was also found to be significantly higher in poplar plantation than in others (Table-1). Organic carbon content to be significantly higher at native forest than afforested systems, but the soil available P in these sites was higher than 20 mg kg^{-1} (Table-1). There was no significant difference between soil available P of the sites. Although soil exchangeable K in *P. taeda* plantation was lower than in poplar plantation, there was no significant difference between exchangeable (Ca^{2+} + Mg^{2+}) in these sites. Clay content was highest at *P. taeda* plantation, whereas sand content was lowest at *P. taeda*.

TABLE-1
MEAN VALUES OF SOME SOIL PROPERTIES IN DIFFERENT LAND USE/COVER SYSTEM

Soil properties	Native forest (broad leaf)	*Pinus taeda* plantation	Poplar plantation
pH	5.71 (013)b	5.65 (0.10)b	6.48 (0.27)a
Organic carbon	7.27 (0.29)a	5.96 (0.95)b	5.95 (0.82)b
Avai. P	26.46 (14.16)a	23.89 (2.69)a	35.06 (10.29)a
Exchang. K^+	313.36 (71.96)ab	221.54 (58.12)b	497.76 (258.95)a
Ca^{2+}+ Mg^{2+}	7.97 (1.09)a	4.26 (1.29)a	8.45 (1.75)a
Clay	12.80 (2.28)b	20.20 (3.49)a	12.80 (2.57)b
Sand	47.20 (4.60)a	35.20 (3.29)b	40.32 (17.52)ab

For a given variable, different letters indicate significant differences ($p < 0.01$).

The results of *Arbuscular mycorrhiza* fungi spore numbers analysis showed that there was significant difference between abundance of *Arbuscular mycorrhiza* fungi spore in the soils of different land use systems (Fig. 1). The highest of *Arbuscular mycorrhiza* fungi spores was observed in the rhizosphere soil of native forest (36.8 spore 20 g^{-1} soil) which was significantly higher than other species studied.

Statistically significant variations were observed in the total percentage of mycorrhizal colonization among the roots of different tree species (Fig. 1). The highest percentage of colonization found among the tree roots of native forest. Most of the *Arbuscular mycorrhiza* fungi encountered in the present study belong to the genus Glomus beside other generic forms like *Gigaspora* and *Acaulospora*.

Correlation coefficients observed in Table-2. Correlation coefficients exhibited that there were no significant relationship between *Arbuscular mycorrhiza* fungi spore numbers and soil clay content (Table-2). However the relationship between *Arbuscular mycorrhiza* fungi spore numbers and soil sand content was positive and significant. The relationship between *Arbuscular mycorrhiza* fungi spore numbers

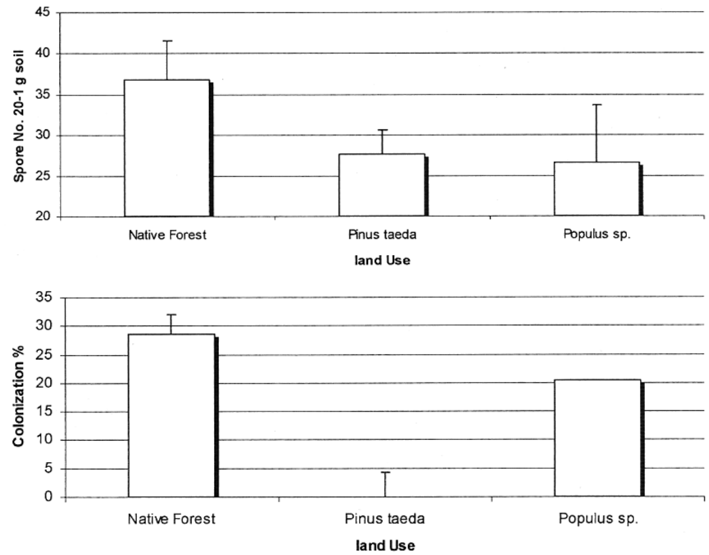

Fig. 1. Status of *Arbuscular mycorrhiza* fungi in the studied sites

TABLE-2
CORRELATION COEFFICIENTS BETWEEN SPORE AND COLONIZATION OF AM FUNGI WITH SOME SOIL PROPERTIES

	Colonization	pH	O.C	K	Av. P	Ex. K	Ca^{2+} + Mg^{2+}	Sand	Clay	B.d
Spore	0.61^{**}	$-0.12^{n.s}$	$0.29^{n.s}$	$0.17^{n.s}$	-0.59^{*}	$0.24^{n.s}$	$0.32^{n.s}$	0.60^{**}	$-0.12^{n.s}$	$-0.12^{n.s}$
Colonization		$0.28^{n.s}$	0.48^{*}	0.63^{**}	$0.08^{n.s}$	$0.35^{n.s}$	0.78^{**}	$0.32^{n.s}$	-0.75^{**}	$-0.38^{n.s}$

OC = Organic carbon.

and available P was negative and significant. The correlation coefficient between *Arbuscular mycorrhiza* fungi spore numbers and organic carbon, K and Ca^{2+} + Mg^{2+} were positive but not significant. The relationship between *Arbuscular mycorrhiza* fungi spore numbers and *Arbuscular mycorrhiza* fungi root colonization was positive and significant. The correlation coefficient between *Arbuscular mycorrhiza* fungi root colonization and K and Ca^{2+} + Mg^{2+} content were positive. However, the relationships between *Arbuscular mycorrhiza* fungi root colonization and clay content was negative and significant.

The largest spore abundance was found in agricultural field, while the lowest ones occur in *Pinus taeda* plantation. According to Paul and Clark[16] *Arbuscular mycorrhiza* typically occur in a soil with low organic carbon. Abundance of *Arbuscular mycorrhiza* fungi spore in afforested soils was markedly low. This situation might be related to their low plant diversity, their affecting on the activity of their micro flora and microfuana. Although *Arbuscular mycorrhiza* fungi are, non-host specific in their ability to infect a wide range of hosts the degree of benefit to each partner in any given *Arbuscular mycorrhiza* fungi-host plant association can depend on the particular species involved[17]. Such differential effects between individual *Arbuscular mycorrhiza* fungi-host partners[18] may influence both host and *Arbuscular mycorrhiza* fungi community structures. The composition of the *Arbuscular mycorrhiza* fungi community may be strongly influenced by the host species through differential effects on hyphal growth and sporulation[19]. Root exudates of different species may differ, influencing the germination and growth of specific *Arbuscular mycorrhiza* fungi species[18]. A large part of the differences between *Arbuscular mycorrhiza* fungi populations in sites might be related to their different plant cover and diversity. Land use and plant density can change soil properties, controlling soil microbial population and activities[20].

Arbuscular mycorrhiza fungi status in the Hyrcanian forest soils depend on the type of land use, management system, plant diversity and root exudates. While present study is limited to only one set of sites, we provided evidence that *Arbuscular mycorrhiza* fungi population can respond to land use practices. As such, *Arbuscular mycorrhiza* fungi status may be useful as a sensitive indicator of land use change in response to such treatments. Further studies are needed to demonstrate the generality of these patterns.

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