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The effect of natural and planted forest stands on soil fertility in the Hyrcanian region, Iran

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ABSTRACT

Rafeie Jahed R, Hosseini SM, Kooch Y. 2014. The effect of natural and planted forest stands on soil fertility in the Hyrcanian region, Iran. Biodiversitas 15: 206-214. In the present work, we studied the effect of natural and planted forest stands on soil fertility in the Hyrcanian region of northern Iran. Natural forest stands (including *Acer velutinum* Bioss., *Zelkova carpinifolia* (Pall), *Parrotia persica* (DC.) C.A.Mey, *Quercus castaneifolia* C.A. Mey., *Carpinus betulus* L, Mixed planted stand (including *Acer velutinum*, *Ulmus carpinifolia* G. Suckow *Quercus castaneifolia* C.A. Mey, *Carpinus betulus* L., *Tilia begonifolia* Scop. subsp. *caucasia* (Rupr.) Loria; maple (*Acer velutinum* Bioss) plantation, pine (*Pinus taeda* L.) plantation and also clear-cut region (control) were considered in this research. Soil samples were collected at two different depths, i.e., 0-15 and 15-30 cm, and characterized with respect to organic carbon (C), total nitrogen (N), available nutrient elements (P, K, Ca and Mg); pH and soil texture. The results showed that the highest amount of total N was found in mixed plantation. The highest amount of available P was detected in maple plantation and pine plantation had the highest available K and organic C than other treatments. The highest and the lowest available Ca and Mg were found in natural forest and control area, respectively. In addition, it was observed that nutrients accumulate in upper layers of the soil. Hardwood stands have been more successful than the conifers stands, so this should be considered in the sustainable management of forests.

Key words: Broad-leaved, needle-leaved, natural forest, plantation, soil nutrients.

INTRODUCTION

There are numerous as well as very complex relationships and processes between the soil and the plant and in recent years, plant scientists and soil scientists have made effort to identify the rules governing this complex system. In this way, many achievements has been gained but still a long way is ahead to understand all aspects of this complex system (Alizadeh 2004). Development of forests through the forestation is inevitable at present and in the future due to the destruction of natural forests in the world, the growing population and increasing the need for wood products and other forest services. Reduced area of natural forests has led forestation with the purpose of forest development and wood production to be of high importance, thus assessment of planted forests will play an important role in establishing forests with better quality and quantity in the future. Forest soil properties including quantity and quality of soil organic matter reserves are depended on complex climatic responses, soil type, management and tree species in soil nutrient cycling between trees and soil (Lal 2005).

Different tree species through their different characteristics in litter production, nutrient release and having specific chemical compounds in their litter play a major role in the nutrient cycling (Rahajoe 2003). Nitrogen (N), phosphorus (P) and potassium (K) reserves are among the important indicators for evaluation the effect of tree species on ecosystem function (Lovett et al. 2002). Numerous studies have been conducted on the effects of tree species on soil properties indicating a significant effect of over story tree species on soil productivity (Binkley and Giardina 1998; Mohr et al. 2005). Schulp et al. (2008) assessed the effect of tree species on carbon (C) stocks in forest floor and mineral soil and implications for soil C inventories and in their the effects of forestation on soil properties were investigated; results revealed a most positive effect of forestation on soil properties and C uptake. Neirynck et al. (2000) found that C/N ratio in topsoil under maple plantation was the lowest compared to other species and some species namely lime (*Tilia platyphyllos*), ash (*Fraxinus excelsior*) and maple (*Acer psedoplatanus*) that generally produces humus had higher pH values than red oak (*Quercus robur*) and beech (*Fagus sylvatica*) species.

The study carried out by Lovett et al. (2002) showed that tree species may affect the cycling of C, N and other nutrients in the soils under their canopies and this, in turn, can influence on substantial processes at an ecosystem level. The study of Hagen-Thorn (2004) on 30 years old plantations showed that tree species clearly influence on different soil properties and this effect is more pronounced at a depth of 0-10 cm of topsoil. Rouhi-Moghadam et al. (2011) investigated some of the soil properties in pure and mixed planted stands of oak (*Quercus castaneifolia*) in Chamestan, northern Iran. They found that tree species planted in different types of plantations can to some extent influence on soil properties so that some of planted treatments caused increased C/N ratio and increased lime and Ca and Mg and to some extent decreased acidity compared to control treatment. It was also found that the upper layer of pure oak treatment had the lowest total N and the highest C/N ratio and this treatment had the highest electrical conductivity (Ec) in its lower layer compared to other planted treatments.

Bakhshipour et al. (2012) studied some soil properties including pH, organic C, P, K, Ca, Mg, soil texture, bulk density and microbial biomass respiration imposed by taeda pine (*Pinus taeda*) and poplar (*Populus deltoides*) plantations. The results indicated that taeda pine plantation showed the higher soil bulk density compared to poplar plantation while poplar plantation represented the higher soil pH and available P compared to other treatment. The specific objective of this study was to quantify the effects of different tree species on selected soil properties, especially fertility, in a part of northern Iran.

MATERIALS AND METHODS

Study area

This study was carried out in forests of Noor County, 4 km apart from Chamestan, Mazandaran province, Northern Iran. Locating at 36° 19' 48"-36° 20' 41" N and 51° 51' 39"-51° 52' 44" E, the elevation in study area varies from 150 m to 250 m a.s.l (Figure 1). Slope in the study area ranges from 0% to 30% and climate is classified as humid according to de Marton climatic classification. Mean annual precipitation and temperature are 997 mm and 16.4 °C, respectively. Parent materials are mostly conglomerate, sandstone and limestone, calcareous marl and partially sand limestone and silty limestone. Forest soils in the study area are brown forest with acidic pH and the alluvial Calcimorph and texture are relatively heavy to heavy clay. The studied stands includes: (i) Natural stand (*Acer velutinum*, *Zelkova carpinifolia*, *Parrotia persica*, *Quercus castaneifolia*, and *Carpinus betulus*) with an area of 22 ha; (ii) Mixed planted stand (*Quercus castaneifolia*, *Carpinus betulus*, *Acer velutinum*, *Tilia begonifolia*, *Parrotia persica*) with an area of 10.1 ha; (iii) Maple stand (*Acer velutinum*) with an area of 14 ha; (iv) Taeda pine planted stand with an area of 16.8 hat, and (v) Control region with an area of 17.2 ha (this part is located in the vicinity of pine planted stands and adjoining the main road was totally clear cut in 1997).

Soil sampling and analysis

In the experimental area, the soil investigations were carried out with the aim of estimating the effect of plantation type on soil properties. For this purpose, four hectare areas (200×200m) were selected for each stand. In order to decrease the border effects, surrounding rows of stands were not considered during sampling. Soil sampling was dug along the four parallel transects in the central part of each afforested stand. Soils were sampled to a depth of 30 cm in all plantations during the summer time using a 7.6 cm diameter core sampler (n = 16 cores/stand using a randomly systematic method) taken at 0-15 and 15-30 cm depths. The same sampling procedure was carried out also for the control area (Kooch et al. 2012).

Figure 1. Location of study area in Chamestan region (O), Noor County, Province of Mazandaran, Northern Iran.

After air drying, soils were passed through a 2.0 mm (20 mesh) sieve to remove roots prior to laboratory analyses. Soil texture was determined by the Bouyoucos hydrometer method (Bouyoucos 1962). pH was measured using an Orion Ionalyzer Model 901 pH meter in a 1: 2.5, soil: water solution. SOC was determined using the Walkley-Black technique (Allison 1975). Total N was determined using the Kjeldhal method (Bremner and Mulvaney 1982). Available P was determined with spectrophotometer by using Olsen method (Homer and Pratt 1961). Available K, Ca and Mg (by ammonium acetate extraction at pH 9) were determined with Atomic absorption Spectrophotometer (Bower et al. 1952).

Data analyses

Normality of the variables was checked by Kolmogorov-Smirnov test and Levene's test was used to examine the equality of the variances. The soil parameters were analyzed by using two-way analysis (ANOVA) procedure, treating plantation and soil depth as factors with interaction. Duncan tests were used to separate the averages of the dependent variables which were significantly affected by treatment. SPSS v.16 software was used for all the statistical analyses.

RESULTS AND DISCUSSION

Results

Soil fertility properties

Among the stands, the highest amount of organic C was belonged to taeda pine forested stand (3.25%). The value of organic C at the first depth (3.45%) was higher the second depth (1.73%), indicating a decrease in carbon storage with increasing depth (Table 1; Figure 2 A). The highest value of total N was reported in mixed plantation (0.29%) followed by pine forest (0.28%), maple plantation (0.25%), natural forest (0.20%) and the control (0.20%), respectively (Figure 2b). total N in the first depth (0.28%) was higher than the second depth (0.21%) (Table 1; Figure 2B). Available P was not significantly different in studied stands and depths (Table 1; Figure 2C). The highest value of available K was observed in pine plantation (295.25 mg/kg) and the values for maple plantation, mixed plantation, control and natural forest were 226.87 mg/kg, 220.37 mg/kg, 202.12 mg/kg, and 199.37 mg/kg, respectively (Table 1; Figure 2D). The highest value of available Ca was found for the control (3300.25 mg/kg) compared to maple plantation, mixed plantation, pine plantation and natural forest with 2300 mg/kg, 2186.31 mg/kg, 2038.75 mg/kg, 1748.75 mg/kg, respectively (Table 1; Figure 2E). The highest value of available Ca was reported for the natural forest (861.8 mg/kg) followed by mixed plantation, control, pine plantation, and maple plantation with 753.75 mg/kg, 721.87 mg/kg, 719.50 mg/kg, 639.25 mg/kg, respectively (Table 1; Figure 2F). Also the highest available K was found in the first depth. Available P, Ca, and Mg did not show significant differences in terms of studied depths (Table 1; Figures 2C-F).

Table 2. ANOVA for soil fertility in the studied stands and depths.

Source of change	Characteristic	F-value	Sig
Stand	C	4.439	.003*
Depth		73.411	.000*
Stand*depth		2.242	.073
Stand	N	4.440	.003*
Depth		15.421	.000*
Stand*depth		1.669	.167
Stand	P	1.048	.389
Depth		.000	.998
Stand*depth		.632	.641
Stand	K	4.791	.002*
Depth		21.212	.000*
Stand*depth		.448	.774
Stand	Ca	6.114	.000*
Depth		2.456	.122
Stand*depth		.413	.799
Stand	Mg	6.114	.000*
Depth		.045	.832
Stand*depth		.768	.549

Note: Different is significant at the 0.05 level.*

Soil physicochemical properties

The results indicated significant differences between the stands in terms of clay content so that the highest clay content was observed in mixed forested stand (53.56%) followed by natural forest stands (45.17%), control (41.37%), taeda pine forested stand (40.75%) and maple forested stand (40.25%) (Table 1). Natural forest stand showed the highest silt content (34.25%) followed by control stands (34%), taeda pine forested stand (32.37%), maple forested stand (28.75%) and mixed forested stand (26.06%) (Table 1). The highest acidity was significantly observed for control stand (7.72) followed by maple forested stand (6.5), teada pine forested stand (6.39); mixed forested stand (6.16) and natural forest stand (5.94). Soil texture components (sand, silt and clay) and acidity were not significantly different in different soil depths (Table 1).

Discussion

In the past decade, the area of plantations has been increased rapidly worldwide. Since 2005, about 140 million ha land have been forested with this year 2.8 million ha planted forest (Del Lungo et al. 2006). Regarding that each year natural forest areas in the north of Iran are reduced due to destruction and intense logging, and on the other hand, wood recruitments had increasing trend due to improvement of population, therefore, plantation with native species and exotic ones in order to rehabilitating degraded forests and providing requirements of society is necessary for this region (Yousefi et al. 2010). The effect of tree species on soil productivity is the result of interactions between trees and all parts of the ecosystem and it is not limited to the effects of trees on mineral soil. For example, the effect of a tree species on soil productivity varies in different parent materials (Augusto et al. 2002). Most of sustainable production concepts in plantations focus on increase or decrease in the amount of nutrients in site, especially in secondary harvesting rotations. Forest soil properties including quantity and quality of soil organic matter (SOM) reserves are depended on complex climatic responses, soil type, management and tree species in soil nutrient cycling between trees and soil (Lal 2005). In fact, one can understand the interaction between forests and soils within the regional climate by considering the role of trees in soil biological cycle (Zarin-Kafsh 2001). Annually trees add several tons of litter to the soil and make some changes in soil properties, since by decomposition of litter carbon and oxygen are emitted to atmosphere and nutrients are returned to the soil (Onyekwelu et al. 2006). In fact, it can be say that different tree species by adding different litter types to the soil make soils with different properties at the same climate, topographic and managerial conditions like the obtained results in our research.

Organic C

According to our result the highest and the lowest C contents (%) were belonged to pine plantation and control, respectively. In general, different tree species play an important role in biogeochemical regulation of ecosystems through stabilization of SOC (Chen et al. 2003), a vital parameter in the formation and maintaining of soil structure, moisture and fertility (Macedo et al. 2008; Craswell and Lefroy 2001), that is found in this research as like. Also, Arai and Tokuchi (2010) in their research regarding the effect of coniferous species on the soil in terms of OM accumulation in Scotland reported that Cryptomeria japonica had higher OM content compared to natural forests, conforming to results obtained for some coniferous species in the viewpoint of greater storage of organic carbon and to some extent consistent with the results of this research. Accordingly, it is possible that Coniferous stands absorb more C compared to hardwood stands. This can be attributed to this fact that C changes in soil gradually and this change is depended on various factors such as vegetation cover, the amount of litter and plant debris, land use type and management (Chiti et al. 2006). In a study by Kooch et al. (2012) the carbon sequestration of soils under forest plantations with Acer, oak, and pine species were estimated. Their results showed that plantation can exert a significant effect on soil characteristics and, also, causes increase in C sequestration of soil so that it was more in the studied species compared with the control site. Moreover, Shi and Cui (2010) concluded that planted species have a positive effect on the soil C.

Thus, despite the results of many studies that show the higher capability of hardwood stands for sequestering carbon in soil, the pine stand makes litter decomposition slow by reducing the amount of light entering into the stand due to its extensive canopy. As a result, high accumulation of litter on the ground and greater soil protection created by coniferous stands make prevent carbon from loss to some extent (Noubakht et al. 2011). Thus, this makes increase in soil C compared to other stands. However, given the same or equal conditions of most factors affecting the amount of carbon in investigated plantation stands other reasons for slight increase in soil carbon of pine stands could be the higher in soil moisture and waterlogging conditions in this plantation compared to other stands. Because mineralization of leaf in some tree species such as pine requires several years (Zarin-Kafsh 2001). This makes to create an insulating coating in the forest floor that prevents evaporation and moisture loss, which provides the conditions for soil macro fauna, including earthworms, which are highly water. More acidic soils will supply lower quantities of nutrients (Cresser and Killham 1993; Holden 2005). Skyllberg (1991) in a study assessed the pH variations in different layers of soils under two stands (Abies and Picea stands) in Sweden and concluded that probably pH and SOM are significantly correlated.

Table 1. Mean (standard error of mean) soil physico-chemical features in stands and depths

	Natural forest	**Mixed plantation**	**Maple**	**Loblolly pine**	**Control**	**Statistic description**
Sand (%)						
D1 (±SE)	21.34 (±2.43)	24.75 (±3.25)	27.09 (±2.59)	31.96 (±3.35)	23.62 (±2.96)	Stand: F=2.09,P=0.09 (Maple> Pine>
D2 (±SE)	20.75 (±2.10)	19.25 (±2.41)	30.09 (±5.75)	22.18 (±2.15)	25.90 (±2.71)	Control> Mixed> Natural)
						Depth: F=1.13,P=0.29
Clay (%)						Stand×Depth: F=1.49, P=0.21
D1 (±SE)	43.77 (±2.13)	52.65 (±3.22)	39.75 (±3.30)	39.5 (±1.99)	40.25 (±2.81)	Stand: F=7.34, P=0.000 (Mixeda>
D2 (±SE)	46.57 (±2.11)	54.48 (±3.33)	40.75 (±3.92)	42.0 (±3.11)	42.50 (±2.47)	Naturalb> Controlb> Pineb> Mapleb)
						Depth: F=1.27,P=0.26
Silt (%)						Stand×Depth: F=0.02, P=0.99
D1 (±SE)	35.25 (±2.64)	25.28 (±1.63)	28.25 (±3.12)	28.75 (±2.13)	36.25 (±1.97)	Stand: F=5.23, P=0.001 (Naturala>
D2 (±SE)	33.25 (±2.29)	26.85 (±1.52)	29.25 (±2.10)	36.00 (±1.92)	31.75 (±2.21)	Controla> Pineab> Maplebc> Mixedc)
						Depth: F=0.22, P=0.63
pH						Stand×Depth: F=2.01, P=0.10
D1 (±SE)	5.98 (±0.14)	6.32 (±0.09)	6.64 (±0.14)	6.28 (±0.06)	7.75 (±0.04)	Stand: F=35.52, P=0.000 (Controla>
D2 (±SE)	5.91 (±0.14)	6.01 (±0.25)	6.39 (±0.34)	6.50 (±0.07)	7.70 (±0.06)	Mapleb> Pinebc> Mixedcd> Naturald)
						Depth: F=0.84, P=0.36
						Stand×Depth: F=0.80 P=0.52

Note: N=16for natural forest,N=16 for mixed plantation,N=16 for maple,N=16 for pine plantaion,N=16 for control.N=8 for soil 0-15 cm, N=8 for soil 15-30 cm. Contrasting letters a, b, c refer to significant differences between different stands (natural forest, mixed plantation, maple, pine plantation, control) and or soil depths (D1=0-15cm, D2=15-30cm).

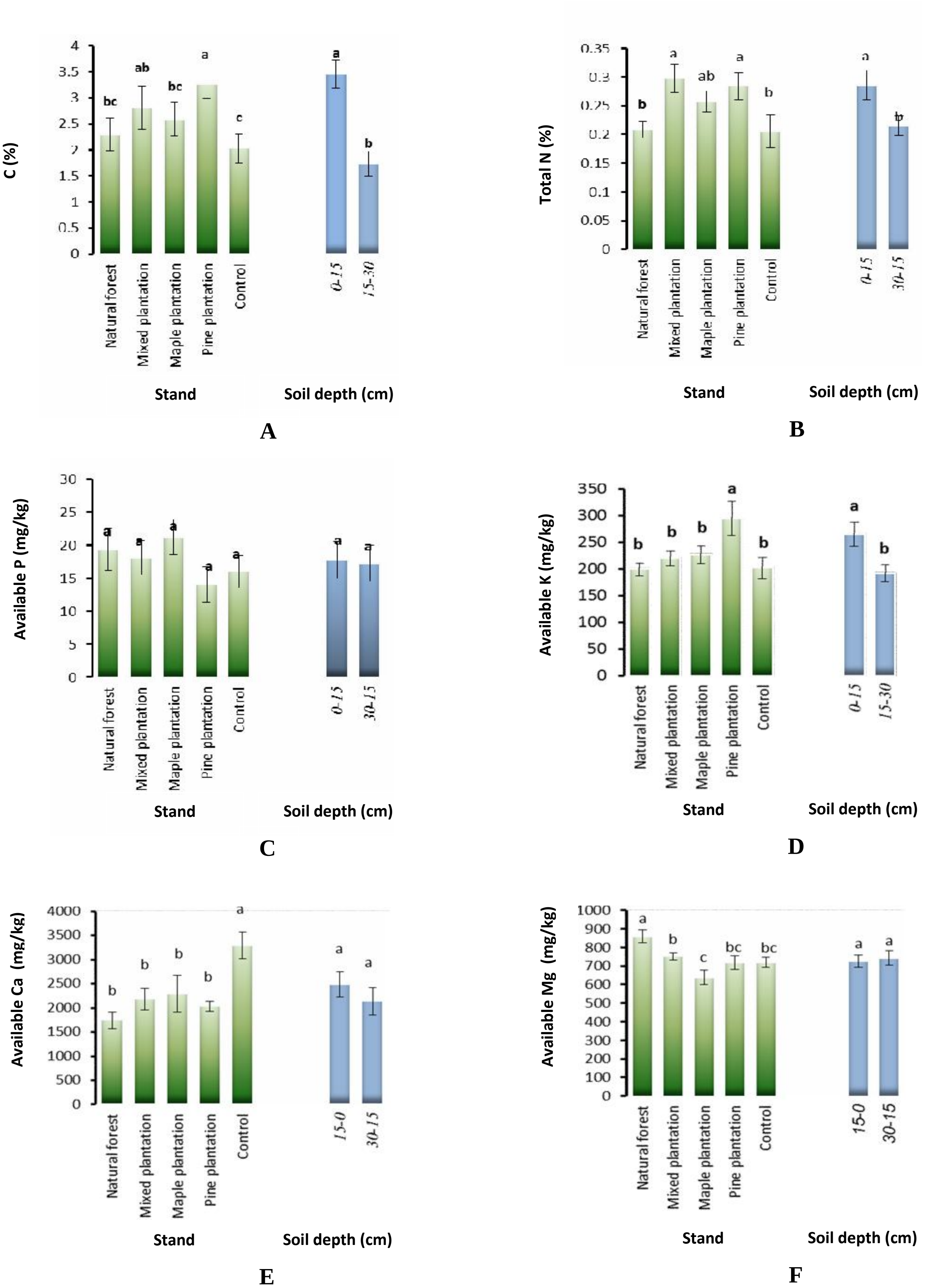

Figure 2. Average values of C (A), Total N (B), available P (C), K (D), Ca (E), and available Mg (F) in different stands and soil depths.

In another study by Smal and Olszewsk (2008), it was concluded that when the OM content decreases, the acidity increases, so the higher C content and acidity in Pine plantation compared to mixed plantation could be attributed to this fact. Banfield et al. (2002) found an exponential relationship between soil texture and biomass C and then the stored soil organic C. Pussinen et al. (2002) in their studies on pine stands in southern Finland concluded that by increasing the soil N content the productivity thereby the amount of carbon stored in long term increases. Some researchers believe that clay content is correlated with the soil organic C (Bauer et al. 1987). Research conducted by Powers and Schlesinger (2002) showed that organic C density is correlated with the soil clay content. Varamesh et al. (2010) also reported clay and N as the most important components influencing the organic carbon stocks and carbon sequestration, and considering a positive correlation between sand content and C as well as a negative correlation between clay content and C it could be noted that the pine plantation had the highest sand content and the lowest clay content compared to other stands and this could be a reason for this claim. Among these studies, we can point out the research conducted by Abdi (2009); he believes that with increasing stone, gravel and sand components in soil texture the soil C sequestration also increases. In this investigation the organic C percentage was higher in the first depth than that the second depth, due to the accumulation of litter on the soil surface and the gradual decomposition process. Higher C content in the surface layers than in the deeper ones has been reported in other investigations including Schuman et al. (2002) that is a reason for this claim.

Total N

In this study, the highest amount of total N was observed in the first depth. It was expected that the available N in the first depth be higher, because litter accumulation as the most important sources of nutrients and SOM are higher in soil surface layers (Buresh and Tian, 1998, Rice 2000; Brady and Weil 2008). Given that the total N in the mixed plantation was significantly higher than other studied plantations and the control, the higher total N in mixed plantation in the present study could be due to several reasons including high diversity and being mixed at the over story due to differences in leaf and branch characteristics, litter quality and quantity, and processes occurring at the forest floor. Another reason could be the higher percentage of organic C in the soil of this stand, because the relationship between total carbon and total N is a positive correlation and it can be considered as a factor causing increased total N in mixed stand (Hagen-Thorn 2004). Because soil total N changes gradually and it depends on various factors such as vegetation cover, the amount of litter and plant debris, land use and management (Chiti et al. 2006). Of other affecting factors, the acidity can be mentioned so that pH influences the amount of nutrient uptake by plants, microbial activity and changes in the of N and C absorption (Augusto et al. 2002).

Usually in more acidic soils the amount of macronutrients is reduced (Holder 2008) since the natural forest had the lower acidity and available N compared to mixed plantation with higher acidity and available N thus decreased total nitrogen in soil under natural forest could be attributed to lower acidity. Viability is positively correlated with increased OM, total C and total N and this relationship is particularly more apparent in soil surface layers decreasing with depth. These elements have a higher influence on viability because the OM serves as the main cause of soil structure formation and causes increased soil porosity and permeability (Quideau et al. 1996; Augusto et al. 2002). Also OM is nitrogen enriched and because of its high adsorption characteristics play an important role in increased capacity of exchangeable elements thereby soil fertility (Craswell and Lefroy 2001; Macedo et al. 2008).

Soil C reserve is correlated with soil clay content, and it has been stated that soil texture effectively influence on the C and N reserves (Moghimian and Kooch 2013). Since the exchangeable cations and nutrients are readily become unavailable in sandy soils but they can be better preserved in clay soils, thus it can be stated that the mixed plantation showed the highest nitrogen content compared to other stands because of its highest clay content and its lowest sand content (Brady and Weil 2008; Gerrard 2014).

Available P

In this study no significant difference was observed for the P in soil surface layers, since this element is less prone to leaching and the P required by plants is provided from subsoil. .However, there may be differences in P content in deeper layers soil due to P present in minerals rocks. This means that the amount of P in subsurface rocks varies, and the amount of P reached to soil changes little over time. The absorption conditions and plant type are also effective. P deficiency in soils under coniferous species compared to hardwoods can be explained by the weaker biological activity of microorganisms in the soil surface organic layers in the soils under conifers (Hagen-Thorn 2004). In the present study no significant difference was found between investigated stands for phosphorus are at the $P<0.05$, consistent with the result with the result of other authors such as Sayyad et al. (2007) and Parrotta (1999). But reporting the highest available P in the maple plantation and the lowest value in pine plantation indicate that the P uptake is affected by vegetation type. Change in soil P is very slow taking a long time (Ardakani 2009). Also in many studies it has been noted that it is difficult to analyze the effect of different species on soil P levels are also (Augusto et al. 2002). The mobility of elements in soil is influenced by their solubility.

Another reason for being the higher available P in maple plantation compared to pine stand may be lower acidity value the former one since there is a direct relationship between acidity and nutrient concentrations. Generally, when soil acidity increases the amount of macronutrients is reduced so that in pine plantation (a coniferous stand) the value of available P is lower due to lower. In several researches, increased available P has been reported in topsoil under plantations (Belton et al. 1995;

Cavelier and Tobler 1998). Available P did not show significant difference at studied depths, but comparison of means indicated a higher available P in the second depth greater compared to the first depth. This is most likely due to recycling of plant residues on the soil surface (Kiani et al. 2007). It is noteworthy that most of available P in forest soils is present in the surface horizons (Zarin-Kafsh 2002) as it is clearly obvious in this study.

Available K

The results of present study showed that the amount of available K in pine plantation was higher than other plantations and the control area. One reason may be the lower need for K thereby the lower absorption in pine plantation causing increased K in soil under to pine plantation compared to other plantations and the control region. Other reasons can be found in the study by Richter and Markewitz (1994) that noted that one of the most important reasons for significant decrease in K value in soils under pine plantation is the dynamics and activity of this nutrient in its cycle. Other reasons for slight increase in soil K of pine stands could be the higher soil moisture and water logging conditions in this plantation compared to other stands. Also it may be reasonable the increased value of nutrients such as potassium in stands, as well as an increase in silt and clay content (Sanchez-Maranon et al. 2002). Soil K as well as phosphorus is an element that has a low mobility under the effect of water and it mostly is dependent on the type of parent materials, in other words the amount of rock and minerals containing K in parent materials and in long-term this nutrient is adsorbed by plants through processes such as physical and chemical erosions (Rouhi-Moghadam et al. 2011).

In this study, higher concentrations of K in pine plantation compared to hardwood maple plantation may be due to the higher silt and clay content in the former, because soils with high clay content in are rich in nutrients (Berthrong et al. 2009). In this research the K in the first depth was higher than the second depth, because litter accumulation as the most important sources of nutrients and soil organic matter are higher in soil surface layers (Buresh and Tian 1998; Rice 2000; Salehi et al.2011), in fact the nutrients in the soil are directly linked to nutrients released by plants and nutrient cycling in the soil surface layers (Dijkstra et al. 2001; Dijkstra and Smits 2002).

Available Ca

Soil Ca is the essential element for plant growth and productivity that plays a major role in the strength of plant cells by producing Ca. Soil Ca is an element that is affected by planting tree species (Fernandez et al. 1999). The results of this study indicate that the Ca in soil under control region was higher than the other stands and the higher Ca concentration in control can be due to the lack or low absorption by tree vegetation, and the low Ca concentration in other stands is because of its absorption by trees. About difference between soil Ca in two studied stands, it could be noted that increasing the OM in forest stands is expected to make increase in CEC and presence of these cations; in addition, litter produced from canopy is also a factor that can annually return large quantity of Ca into the soil (Dahlgren and Singer 1994). However, it seems that the presence of these cations, particularly the Ca controlled by lime, in soils causes significant increase in concentrations of these cations in soil under control region. One reason for the increased Ca in control region may be the negative relationship between canopy and lime, Ca and Mg concentrations showing that in one hand decreased canopy cover can decreases the entering litter, and in the other hand by decreasing the canopy cover its protective effect reduces as a result by increasing erosion and leaching in soil the solubility of lime increases thereby the concentrations of Ca and Mg increase. It seems that in calcareous soils, the presence of these cations, particularly calcium is controlled by lime cause significant increase in cations in the soil under control region (Salehi et al. 2011).

As more acidic soils nutrient provide lower amount of nutrients, the high pH may be another reason for the higher concentration of this element in this stand. Also comparison of the means showed that Ca in the first had higher concentration than the second depth confirming the results of Rouhi-Moghadam et al. (2008) and Haghdoost et al. (2011). According to Finzi et al. (1998), the difference between Ca concentration in the soils under hardwoods and conifers is the higher accumulations of Ca in litter produced by hardwoods as well as the higher litter produced by these plants compared to conifers and in the present study the coniferous stand had the lower Ca concentration than hardwood planted stands. Augusto et al. (2002) stated that some tree species in Europe make reduced soil nutrients, such as Ca and Mg. Sayyad et al. (2007) also has reported lower calcium levels in plantations compared to control treatment that correspond the results of our study. Johnson et al. (1995) also has reported the higher calcium leaching in pine stands (*Pinus taeda*) than hardwood stands. According to Ritter et al. (2003) after plantation the acidification of surface soil starts which may cause a decrease in Ca concentration in the surface soils under planted coniferous stands. However, Alriksson and Eriksson (1998) reported that the highest concentration of Ca was found in the surface soil under 55-year-old plantations of spruce (*Picea abies* L) and they believe that transportation of cations from deeper layers of soil to surface layers may occur.

Available Mg

Most of forest soils in Iran are rich in Ca and Mg, and even concentrations of these nutrients are much more than plants need. There may be possible shortages of these two elements in soils with a pH less than 5.5 (Zarin-Kafsh 2001). Also, the results of this study indicated that the highest levels of available Mg were found in soils under natural forest stands. According to Hagen-Thorn (2004) conifer species compared to hardwood stands, due to higher tendency to absorb base cations namely Ca and Mg make reduced concentrations of these nutrients in the soil and in this study also Pine plantation showed the lower available Mg compared to most of hardwood stands. The higher concentration of magnesium in pine plantation compared to maple plantation may be due to higher sand content in maple stand, perhaps due to the proximity of the stand to the rivers and changes in groundwater table during different seasons resulted in lower concentrations of these elements to be stored.

Coarse-textured soils are of low fertility in terms of nutrient requirements. Since soil texture plays an important role in determining many of the soil chemical properties namely maintaining and exchanging the soil exchangeable cations (Ashman and Puri 2002). And the silt and clay contents in soil under natural forest stand was ratio the highest value, therefore the soil of this stand is fine-textured and has low permeability and good water holding capacity than light soils and is a nutrient-rich soil (Zarin-Kafsh 2001). Although the concentration of this element did not show significant differences in terms of depth, the comparison of means showed the highest concentration of the element in the second depth and the higher concentration of the element in subsoil may be due to the parent limestone underneath of the region and its low concentrations in the surface soil may be due to leaching in addition to absorption by the trees (Rouhi-Moghadam et al. 2011).

CONCLUSION

The aim of this study was to investigate some of soil physical and chemical properties in different land cover and to compare the effect of each species on some of the soil fertility features in the same climatic and topographic conditions. The results show that in the case of all macro-nutrients, except for Ca, the studied stands were more successful than the control area indicating the positive impact of forestation on soil fertility indices. According to the results of the study among all stands in terms of K, and C percentage, the pine plantation and in the viewpoint of other nutrients the hardwood stands have been more successful, respectively. Overall, it could be concluded that hardwood stands have been more successful than the conifers stands, so this should be considered in the sustainable management of forests. However, reasons for these observed differences among species cannot be explained certainly and definitely. But the contribution of all factors must be examined. Since in this study the difference between the effects of composition of planted species on soil properties can be found in both soil layers.

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