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Masoomeh S. Rahimabady
Moslem Akbarinia
Yahya Kooch

Authors' address:
Faculty of Natural Resources & Marine Sciences; Tarbiat Modares University, 46417-76489, Noor, Mazandaran, Iran.

Correspondence:
Moslem Akbarinia
Faculty of Natural Resources & Marine Sciences; Tarbiat Modares University, 46417-76489, Noor, Mazandaran, Iran.
Tel: +98-122-6253101(3)
e-mail: akbarim@modares.ac.ir

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The effect of land covers on soil quality properties in the Hyrcanian regions of Iran

ABSTRACT

The present study examined the effect of land covers on some of soil quality properties. For this purpose three plantation stands (*i.e.*, *Alnus subcordata* L., *Poplus deltoids* L. and *Taxadium distichum* L. Rich) and an uncultivated land (control area) were considered. Soil samples were collected at two different depths (0-15 and 15-30 cm) and characterized with respect to water content, pH, texture, total organic carbon and nutrient stocks (N, P, K, Ca and Mg). Our findings showed that the highest values of sand, clay and total organic carbon were detected in *Alnus subcordata* L., *Poplus deltoids* L. and *Taxadium distichum* L. Rich, respectively. Whereas the highest of pH, water content and silt were observed in the control area. Measurements of soil nutrient stocks showed that fertility decreased in relation to increased soil depth, with significant differences depending on soil depth. As a conclusion, the broad-leaved species were more successful about most of nutrient stocks than needle-leaved stand and control area.

Key words: plantation, broad-leaved, needle-leaved, nutrient stocks, soil

Introduction

Soil quality is a concept that includes soil physical, chemical and biological factors and it is used as a framework for the evaluation of soil (Khormali et al., 2009). Land use change considerably influences on soil quality, especially on organic matter (OM) and structural stability (Caravaka et al., 2004). In fact, the different land cover such as forestation with native and non-native species can potentially cause changes in the evolution of ecosystems, including changes in soil carbon storage, reduced soil nutrients, increased biomass; soil acidification and return the nutrients to trees (Berthrong, et al., 2009). In addition to influencing on environment and economy, forestation with native and non-native species affects soil physical and chemical properties (Ardakani, 2002). Thus different tree species, through their different properties in terms of produced litter, released nutrient and chemical composition of litter, play a substantial role in nutrient cycling (Kooch, et al., 2012) and as living organisms influence on the environment and also are affected by it. For maintaining a forest sustainable, soil nutrient should not be significantly decreased, and no significant negative changes in soil properties should be happened (Rouhimoghaddam, et al., 2011). Considering the different effect of each species on soil properties, understanding the soil characteristics is a principle of suitable forest management (Mao et al., 2002; Mathers & Xu, 2003; Chen et al.,2004) because for creating a sustainable forest maintaining of soil nutrients has great importance. Many studies have been done about the effect of tree species on soil chemical and physical properties (Antunesa, et al., 2008; Luan, et al., 2010; Vesterdal, et al., 2008; Vesterdal, et al., 2013).

Dahlgren et al. (2003) observed a higher amount of OM in the soil under forested oak stand compared to bare lands (control). Mishra & Sharma (2003) suggested that the forestation with leguminous tree species reduces the soil acidity. Jeddi & Chaieb (2010) found that forestation with *Pinus halapesis* enhanced soil OM, total N, available P and moisture. In evaluating the effects of forestation with coniferous species in the temperate zones it was observed that forestation caused changes in some soil chemical properties such as reduced pH and increased nutrient uptake (Farley & Kelly, 2004). Chirino, et al. (2010) evaluated the soil properties in forested areas with *Pinus radiata*, *Eucalyptus nitens* and *Cupressus macrocarpa*. Results showed that soils in forested areas had the lower total N and OM compared to grasslands soils but available and organic P were higher in forested areas. Majaliwa et al. (2010) assessed the influence of land cover on some soil physical and chemical properties. In this study, three land-uses namely natural forest, eucalyptus plantation and tea farm were examined in south-western part of Uganda; it was found that the highest clay value observed in forestation area and acidity in tea farm land-use was the lowest. Total N values in all land-uses showed no significant difference and values were approximately equal.

Wang et al. (2011) observed the positive effect of conversion of agricultural land into larch (*Larix gmelini*) forests and suggested that forestation with the species can enhance soil OM storage and improve the physical properties of soil surface layers. Yousefi & Darvishi (2013) compared the soil changes induced by conifers and broad-leaved forestations (*Pinus brutia, Popolus nigra, Acer velutinum, and Fraxinus excelsior*). Results showed that soil OM content in surface layers of the forested areas was higher than other layers. Available Ca and K in forested stands were significantly lower than natural forests, but the amount of Mg showed no significant difference between the various studied stands. The specific objective of this research was to quantify the effects of different tree species on selected soil properties, especially fertility, 13 years after planting in a part of northern Iran.

Materials and Methods

Study area

The study area (Forest Seed Centre of Khazar) is located in the southern of Mahmudabad city, in Mazandaran Province, north of Iran. This area expends between 36°38"N and 52°16"E latitudes and longitudes respectively (Figure 1).The study plantations composed of *Alnus subcordata* L., *Poplus deltoids* L. and *Taxadium distichum* L. Rich. These plantations were planted in 2001. The mean of maximum and minimum temperature were 24.4 (in June) and 7.6 (in December), respectively. The most of annual precipitation were 163 mm (in October). The climate is temperate moist and the mean of altitude from sea surface at the plantation site is 30 m nearly. The region total slope is facing north.

Soil sampling and laboratory 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 (covered by sparse herbaceous species including *Urtica dioica, Sambucus ebulus, Graminae, Ruscus* sp.).

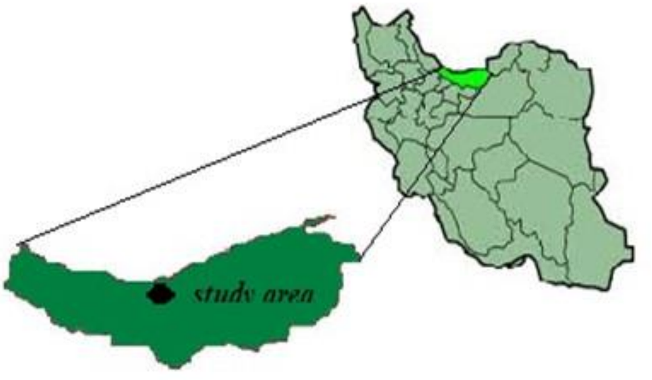

Figure 1. *Location of the study area in the Mazandaran province, north of Iran.*

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 & Mulvaney, 1982). Available P was determined with spectrophotometer by using Olsen method (Homer & Pratt, 1961). Available K, Ca and Mg (by ammonium acetate extraction at pH 9) were determined with Atomic absorption Spectrophotometer (Bower et al., 1952). The nutrient stocks were calculated (Huth, 2010) following measuring the soil bulk density by Plaster (1985) method (clod method).

Statistical 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

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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

Sand was non-significant greater in the *Alnus subcordata* stand compared with the other stands and control area. Sand was non-significant higher at 0 - 15 cm depth than at depths of 15 - 30 cm (Figure 2a). Silt was significantly greater in the control area compared with the stands. Silt was non-significant higher at 15 - 30 cm depth than at depth of 0 - 10 (Figure 2b). Clay was non-significant greater in the *Poplus deltoids* stand compared with the other stands and control area. Clay was non-significant more at 0 - 15 cm depth than at depth of 15 - 30 (Figure 2c). Soil pH was significantly higher in the control area than in the stands. pH was significantly higher at 15 - 30 cm depth than at depth of 0 - 15 (Figure 2d). Water content was non-significant greater in the control area compared with the stands. Sand was non-significant higher at 0 - 15 cm depth than at depths of 15 - 30 cm (Figure 2e). Soil organic carbon (SOC) was non-significant greater in the *Taxadium distichum* stand compared with the other stands and control area. SOC was greatest at the 0 - 15 cm depth and decreased as depth increased (Figure 2f). The mean of soil nutrient stocks are presented in Table 1.

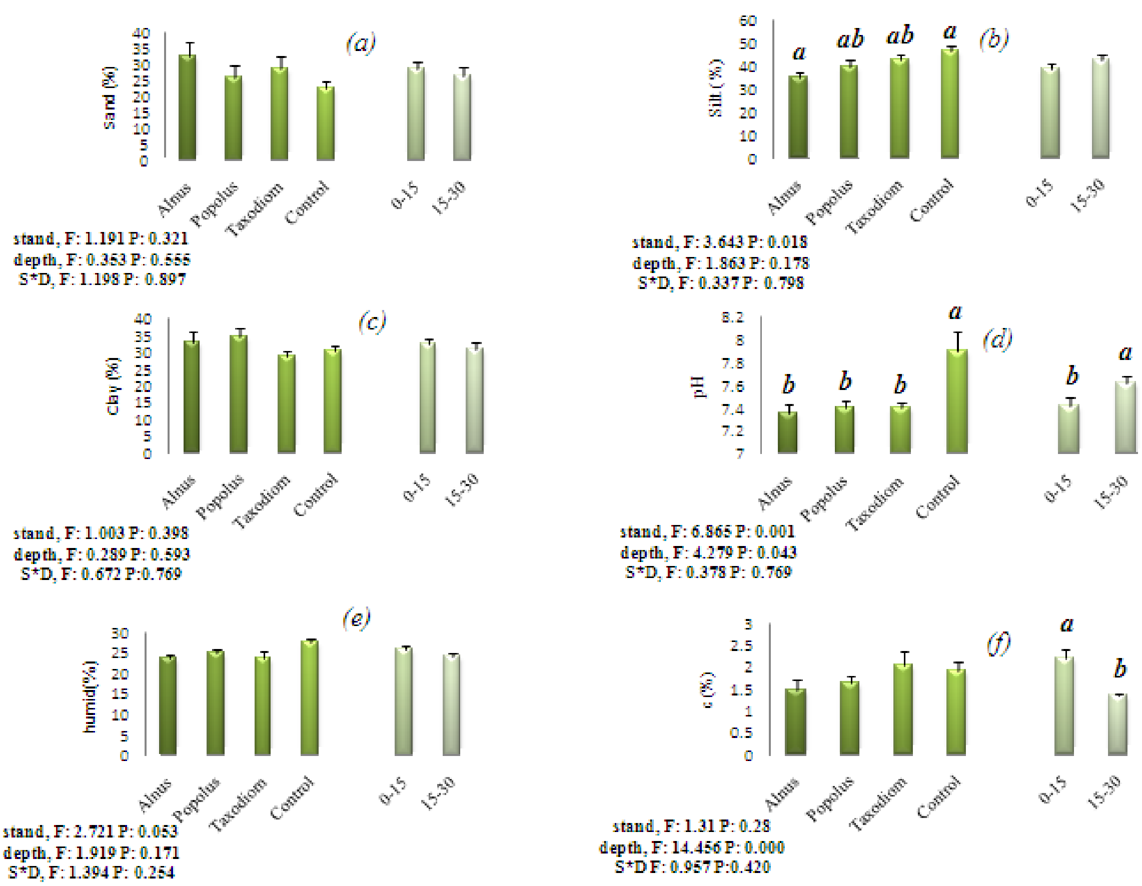

Figure 2. *Mean amount of sand (a), silt (b), clay (c), pH (d), water content (e) and soil organic carbon, SOC (f).*

Table 1. *Mean (standard of mean) soil nutrient stocks in different stands and depths*

	Alnus	Popolus	Taxodiom	Control	Statistic description
N (t/ha)					Stand, F: 3.588 P: 0.019 (Taxodiom^{a}>Alnus^{a}>Popolus^{ab}>Control^{b})
D_1	± 1.33)(8.99	5.30(±1.42)	7.82(±2.07)	3.68(±0.64)	Depth, F: 1.74 P: 0.19 (D_1>D_2)
D_2	5.10(±1.92)	6.27(±0.69)	6.51(±1.11)	2.88(±0.73)	S*D, F: 1.11 P: .35
P(t/ha)					Stand, F: 4.76 P: 0.005 (Alnus^{a}>Popolus^{a}>Taxodiom^{a}>Control^{b})
D_1	0.04(±0.00)	0.032(±0.00)	0.04(±0.00)	0.02(±0.00)	Depth, F: 0.239 P: 0.627 (D_1>D_2)
D_2	0.04(±0.00)	0.037(±0.00)	0.027(±.00)	0.01(±0.00)	S*D, F: 1.130 P: 1.130
K(t/ha)					Stand, F: 23.88 P: 0.000 (Popolus^{a}>Taxodiom^{b}>Alnus^{b}>Control^{b})
D_1	0.32(±0.049)	0.635(±0.089)	0.32(±0.03)	0.26(±0.07)	Depth, F: 7.725 P: 0.007 (D_1^{a}>D_2^{b})
D_2	0.20(±0.03)	0.586(±0.06)	0.21(±0.02)	0.12(±0.03)	S*D, F: .275 P: .843
Ca(t/ha)					Stand, F: 1.625 P: 0.194 (Alnus>Popolus>Taxodiom>Control)
D_1	1.35(±2.03)	12.06(±1.19)	13.617(±1.56)	12.62(±0.51)	Depth, F:0 .268 P: 0 .607 (D_2>D_1)
D_2	1.57(±1.51)	14.80(±1.10)	12.43(±1.51)	10.85(±O.56)	S*D, F: 1.457 P: 0.236
Mg(t/ha)					Stand, F: 2.683 P: 0.055 (Alnus>Taxodiom>Control>Popolus)
D_1	1.70(±0.34)	0.98(0.10)	1.47(±0.33)	1.21(±0.11)	Depth, F: 2.598 P: .113 (D_1>D_2)
D_2	1.40(±0.34)	0.82(±0.11)	1.08(±0.24)	0.96(±0.07)	S*D, F: 0.086 P: 0.967

Discussion

Production capacity of a forestation is highly dependent on availability of soil nutrients which is influenced by management activities and species (Binkley, 1997). Tree species influence on soil through functional traits such as concentration of nutrients in tissue as well as stand characteristics such as nutrients stored in wood and soil biogeochemical cycles (Mueller et al., 2012). Considering the destruction world's natural forests, population growth and the growing need for wood and other forest services, nowadays, the importance and necessity of forestation is highly obvious (Mayani, et al., 2013). But what is important is choosing appropriate species for forestation to improve climatic conditions and soil properties in addition to providing the economic and social needs. Thus, the study of soil properties under each species is an approach to evaluate the performance of that species. Evaluation of soil properties in the present study showed that the totally forested stands represented a higher ability to sequester macro-elements compared to control lands. Therefore, forestation will improve and increase soil productivity properties.

Soil texture plays a key role in determining many soil chemical properties such as exchange and movement of base cations (Kooch & Zoghi, 2014). Soil texture as a physical factor can affect the amount of soil OM and sequestration of nutrients, such as carbon (Nobakht et al., 2011; Varamesh et al., 2011). So that soil rockiness percentage is positively correlated with OM content while clay percentage represents a negative correlation with OM (Varamesh et al., 2011). In this research, soil texture was classified as clay loam in both forested stands and control region. Despite the lack of difference between soil textures classes in this study, there were significant differences in terms of silt percentage so that the highest percentage of silt was observed in abandoned lands (control). Abandoned lands are different from forested stands in terms of vegetation cover and diversity. Vegetation type and density may be among processes influencing on amount particles constituting soil texture (Bakhshipour et al., 2012). Given the small size of silt particles and higher soil moisture in abandoned lands, apart from vegetation type and density, leaching and surface runoff influences the occurrence of differences between silt particles due to their small size. Bakhshipour et al. (2012) suggested leaching and surface runoff processes as factors influencing the reduction of clay particles in addition to vegetation type and density.

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Acidity is one of the chemical indices that issued in soil quality assessment (Schoenholtz, et al., 2000) and is considered among the most important features in site productivity capacity. In the present study the highest acidity is significantly related to the control region, and in similar climatic conditions forest soils show a more tendency to be acidic compared to grassland or pasture soils (Chapin, et al., 2002; Schlesinger, 1997). The higher production of organic acids and carbon dioxide due to higher autotrophic respiration in forest soils are among the factors causing difference in acidity of pasture soils compared to forested land (Richter & Markewitz, 1995). The amount of nutrient absorbed by trees, microbial activity and changes in N and organic C absorption are pH dependent (Augusto, et al., 2002). In many studies soil acidification has been reported as a feature of forestation with conifers (Berthrong, et al., 2009; Smal & Olszewska, 2008; Augusto, et al., 2002; Jackson, et al., 2005). As a result, it is believed that the biological activities of coniferous forests, such as *Taxodium*, spruce and scot pine is weaker than hardwoods (Braun, 1950). However, there are differences between conifers in terms of influence on soil properties and rates of litter decomposition in some tree species such as *Taxodium* and Douglas-fir is higher than spruce and scot pine (Conner, 1994), litter accumulation is low thereby its adverse effects on soil productivity and pH is much lower. In this study the acidity in second depth was significantly higher than the first depth. Given the higher accumulation of OM in the soil surface layers and an indirect relationship between acidity and OM decreased soil pH in the first depth is explainable (Kooch & Zoghi, 2014). The pH value decreases with increasing soil OM (Smal & Olszewska, 2008) because by increasing OM the carbon dioxide derived from OM decomposition increases thus carbonic acid in the soil increases by increasing the levels of CO_2 and this causes reduced pH (Nourbakhsh, et al., 2003).

Organic C (OC) is one of the soil quality indicators that facilitate the accessibility to nutrients (Doran & Parkin, 1994). In this study, the highest amount of OC was found in soil under *Taxodium* stand. Changes in soil OC are gradual and these changes are dependent to various factors such as vegetation percentage, the amount of litter and plant debris, land use and management (Chiti, et al., 2006). Thus, *Taxodium* stand causes slow litter decomposition due to high stand density and wide canopy and reduced light entering into the stand. Accumulation of litter on the soil surface and higher soil protection in conifers stands has a considerable effect on preventing OC from loss and accordingly conifers are able to absorb more carbon compared to hardwoods (Canell, 2003). Percentage of OC in first depth was significantly greater than the second depth in forested stands and control regions; Schuman (2002) has suggested higher OC in soil surface layers. A higher OC content in the soil surface layer is expected. Since accumulation and the presence of litter, as the most important sources of nutrients and soil OM, is higher in the soil surface (Buresh & Tian, 1998; Yousefi & Darvishi, 2013) and in fact, soil nutrients are directly correlated with nutrients released by plant as well as the active cycling in soil surface layers (Dijkstra et al, 2001; Dijkstra & Smits, 2002).

Comparison of nutrient stocks in stands and studied depths showed that soils under forested stands had a higher ability to maintain and protect macro-elements compared to abandoned lands. Only *Poplus deltoids* forest indicated weaker performance to store Mg compared to control region. The results of Augusto et al. (2002) research stated that some European tree species reduced soil nutrients, such as Mg. In fact, decreased concentration of some nutrients in soils under forested areas can be attributed to the depletion of these nutrients in forestations (Onyekwelu et al., 2006).

Conclusion

The results of present study indicate a positive impact of forestation on soil productivity properties of the area. Since forestations are more successful than control regions in terms of maintaining the nutrient stocks. Given the positive impact of forestation on soil productivity properties and considering the fact that level of some important nutrients such as N and OC in soils under *Taxodium* stands is higher than deciduous stands, introducing conifers such as *Taxodium* can enhance some macro-element nutrients such as N in soil organic and mineral layers in addition to preventing the C from loss, thus, the positive effect of forestation on soil nutrients can be significantly increased.

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