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Response of earthworm's biomass and soil properties in different afforested type areas in the North Iran

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Abstract

The study was conducted to evaluate the effects of spruce (*Picea abies*), alder (*Alnus subcordata*), and spruce with alder and maple (*Picea abies* with *Alnus Subcordata* and *Acer cappadocicum*) plantations on the soil properties and earthworm's abundance and biomass in the Lajim, north of Iran. Soil sampling with 50 × 50 cm samples to 50 cm depth in the studied stands was conducted in order to measure soil and earthworm abundance and biomass. Soil texture, C, N, pH, K, and P were measured in all samples in the laboratory. Earthworm's abundance was measured by handpicked and dried for 48 h at 60 °C and then the biomass was measured per unit area. The results showed that the percentage of organic carbon, N, and C/N ratio reached the climax and acidity had the lowest value in spruce stand, and K was significantly higher in alder stand. The maximum and minimum abundance of earthworms was observed in alder and spruce stands, respectively. The results of this study support the effects of plantations on soil properties, earthworm abundance, and biomass.

Keywords: Alder, earthworms, plantation, soil, spruce

Introduction

Because of forest degradation and increase in population, plantation is a vital issue for now and the future. Due to the reduction in forested areas and the shortages in obtaining sufficient amount of forest products, Iran has developed a new policy on forest management. The new policy promotes developing plantations to reduce the need for excessive and early harvesting of natural forest trees and strong dependence of wood industries on the natural forests' products (Asadi, 2001). Plantation with native and nonnative species besides the environmental and economic effects, has a significant impact on the fauna and flora variety of forest floor and physical and chemical properties of forest soil and subsequently can make adverse effects such as loss of biodiversity, the increase of soil acidity, and the reduction of soil micro and macro organisms especially earthworms in temperate climate (Razavi, 2010). Tree composition is one of the main factors determining the soil properties in the long term (Augusto et al., 2002). In addition, Tree species have different effects on soil including biological, chemical and physical properties (Antunes et al., 2008). The importance of soil organisms in the formation and maintenance of soil fertility and structure is not completely understood by soil scientists. Soil fauna is considered as the most important factor in assessing the soil health that its abundance and biomass are influenced by ecological conditions of the site (Moghimian and Kooch, 2013). Moreover, soil fauna is considered as the important component in forest ecosystems due its significant role on decomposing the organic matter and transporting the nutrients (Yang and Chen, 2009). Soil fauna such as earthworms accelerates the decomposition of organic matter and mineralization of nutrients (Rashid et al., 2014). The earthworms are introduced as soil ecosystem engineers because they affect the physical, chemical, and biological properties of the soil (Uchida et al., 2004) and also are one of the important components of soil formation, structure, and fertility (Edwards, 1994). Depending on the

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environment type and ecosystem function, earthworms are splitted into three classes of Litterfall, Litterfall and soil fauna and soil fauna. The effective degree of earthworms depends on their ecological group, size, soil parent material, and climate (Shen and Yang, 2008). Physical, chemical and biological features of soil are essential for soil fertility and ecological classification (Schoenholtz et al. 2000). Forest stand composition and density directly and indirectly affect soil organisms and inorganic soil fauna has significant promotes on humification and can influences the soil nutrients. Pure and mixed plantations have different effects on the soil particularly via their humus type, litterfall quality, and lignin content. Hence, evaluating the success of reforestation activities in rehabilitation and development of destroyed areas is necessary. The purpose of this study was to evaluate the effect of different plantation on many earthworms and soil physical and chemical properties.

Material and Methods

Site description

The present study was conducted in Lajim region located in Mazandaran province, north of Iran, with 965 meters above sea level, 20 percent of the general slope, and longitude 26.5° N and latitude 53.10° E (Figure 1). The studied stands include the species of spruce (*Picea abies*), alder (*Alnus subcordata*), spruce with alder and maple (*Picea abies* with *Alnus Subcordata* and *Acer cappadocicum*). The regional climate is humid-temperate on the basis of Domarten climate system. Soil characteristics include undeveloped soil, profile of AC to AC (B) C, pH of weak alkaline to neutral, parent limestone, clay soil, poor drainage, and rooting medium (Aqbash et al., 2002).

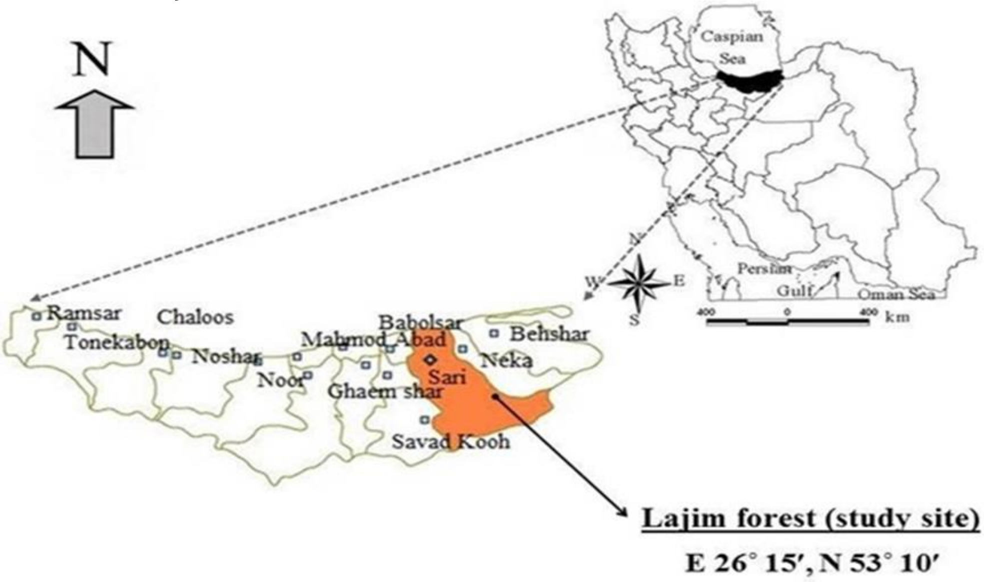

Figure 1. Study site location in the Mazandaran Province, Hyrcanian forests, in north of Iran.

Methods

Ten soil samples were randomly collected from each afforested type. Whole of soil earthworms were collected using plots of 50 × 50 cm to 50 cm depth. The samples transferred to lab then the earthworms in them were manually separated. Subsequently, the samples were dried for 48 h at 60° C in oven. Finally, after weighing the dried samples, earthworm biomass was measured per unit area (m^2). Soil samples were kept simultaneously with earthworms sampling and then conveyed to laboratory due to physico-chemical analysis.

Soil samples were air dried and crushed to pass a two-mm sieve before size fractionation and chemical analyses. Soil physical characteristics such as texture was measured by Hydrometer Method and chemical properties such as pH by potentiometric method using a pH meter, total N by Kjeldahl method, organic carbon by Walkey-Black method, K by flame photometry and P by spectrophotometer were measured (Ghazanshahi, 1997; Jafari Haghighi, 2003).

Statistical Analyses

The normality of the data was evaluated using Kolmograph-Smirnoff. ANOVA and Duncan's test were used to indicate differences and no differences in soil characteristics and the abundance and biomass of earthworms in the three studied stands. All data were submitted in SPSS 16.0.

Results

Earthworm's abundance and biomass

The results showed that earthworm abundance in alder stands was significantly more than that in other stands (Figure 2), while there was not fount a significant difference for earthworm biomass among all stands. The following analysis of earthworm biomass results indicated that despite the lack of significant differences between the different populations studied,the maximum amount of this attribute has been observed in the alder stand (Figure 3).

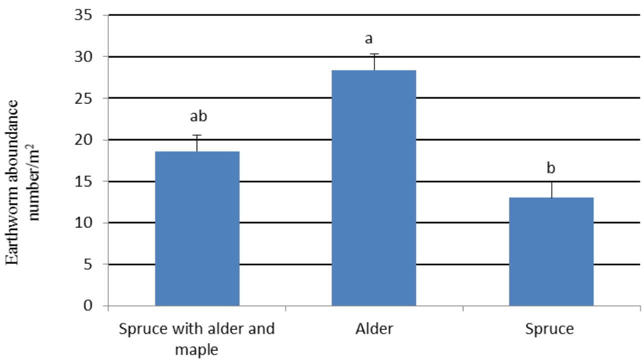

Figure 2. The mean comparison of earthworm aboundance in the stands. Different letters indicate significant differrence (P< 0.05).

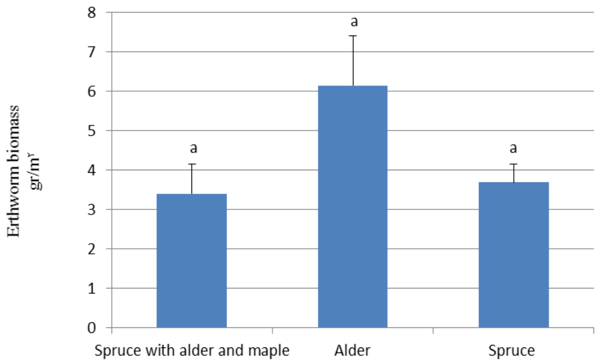

Figure 3. The mean comparison of earthworm biomass in the stands. Different letters indicate significant differrence (P< 0.05).

Physical and chemical characteristics of the soil

Soil analyses indicated the presence of significant differences among all stands with respect to sand, silt and clay contents (Table 1). The results indicated that pH of the soil under the spruce stand was significantly less than that other stands (Table 1).

Table 1. Soil chemical and physical properties in the three stands (mean ± standard error)

Property / Stand	Sand, %	Silt, %	Clay, %	Bulk density, gr/cm²
Spruce	10±0.56 a	26.5±0.37 a	63.5± 0.24 c	1.37±0.03 a
Alder	8±0.6 b	24±0.57 b	68±0.61 b	1.07±0.02 c
Spruce with alder and maple	9±0.56 ab	17±0.6 c	74±0.56 a	1.26 ±0.05 b

pH	Organic C, %	Total N%	C/N	P, %	K, %
4.31±0.03 c	2.3±0.03 a	0.09±0.004 a	26.74±1.32 a	24.4±0.64 b	256.25±1.66 b
6.15±0.12 b	0.65±0.02 c	0.06±0.005 b	11.63±1.39 c	24±0.54 b	191.55±1.48 c
6.75±0.07 a	1.13±0.03 b	0.07±0.01 b	15.28±1.32 b	26.80±0.72 a	311.60±1.88 a

Different letters indicate significant differences (p<0/05) between different stands

ANOVA results indicated that the organic carbon was significantly higher among the stands so that the highest and lowest value were recorded in spruce and alder, respectively (Table 1). The results analyses indicated total N was significantly different among all stands (Table 1). Results of ANOVA showed that the C/N ratio in the stands studied showed a significant difference as the largest and lowest amount of it were in spruce and alder, respectively. Comparison of means of K in alder, spruce, and spruce with maple and alder stands orderly increased and significantly were different (Table 1). Also, comparison of means of P in the spruce with alder and maple stand was significantly more that in other two stands (Table 1). ANOVA results indicated the presence of significant differences among all stands with respect to bulk density of soil so that the maximum and minimum were recorded in spruce and alder, respectively (Table 1).

Discussion

Forest species can cause different changes in soil properties which due to species type, stand age, and biomass growth. Immediately after the plantation, small and gradual changes occur in physical, chemical and biological parameters of the soil. Influence of tree species on soil fertility is the result of interactions between trees and all components of the ecosystem and only the species effect varies on soil fertility in different areas (Augusto et al., 2002). Planting by fast-growing species is one of the most effective ways of demand for fuel, wood and biomass. Choosing a suitable species depends on its adaptability, survival ability, optimal growth, and toleration of positive or negative changes in the soil.

Physical and chemical properties

Significant differences in soil characteristics have shown among the stands. pH affects soil physical, chemical and biological properties and has an eminent compact on plantation performance through effects on the availability of essential nutrients and the solubility of toxic elements (Rhoades and Binkley, 1996). The minimum pH was observed in spruce stand which can be due to the slow decomposition of spruce litterfall. Different authors have shown that conifers reduce the soil pH and the litterfall layer of conifers is more thicker than that in hardwoods (Zhang et al., 2012). Augusto et al. (2002) showed that soil acidity in spruce stands were lower than that in beech and oak stand. Obviously, changes in soil acidity can lead to changes in nitrogen uptake, activity of soil microorganisms, and nutrient uptake by trees (Khanhasani et al., 2009). Organic carbon, as a functional and structural component of soil fertility, has been most commonly used in management of forest soils and site richness (Moghimian and Kooch, 2013). N plays an important role in the decomposition of organic material, so that a high concentration of N in the fresh litterfall can accelerate the decomposition process (Agren et al., 2001). C/N ratio is an indicator of humus and litterfall decomposition, and thereby weight and volume loss of litterfall can be measured (Taylor et al., 1989). The results indicate the amount of C and N in the soil are significantly different in the stands that spruce has reached the maximum of them. It appears that the accumulation of litterfall on the soil surface doesn't permit C to leave the soil. Nobakht et al. (2011) revealed that Norway spruce uptaked more N from the soil which it played an important role on increasing soil organic carbon. C/N ratio showed a significant difference among stands which the maximum amount of it was found in the spruce stand. High ratio of C/N as an index of slow litterfall decomposition shows that organic matter increases in soil surface horizons.

Cannel and Dewar (1993) concluded that coniferous species increase the density of surface litterfall and in other words, causes soil organic carbon. K and P in spruce with alder and maple were maximum which this value is due to rapid decomposition of alder and maple litterfall and then rapid decomposition of litterfall releases the high concentration of cations in the soil (Yugai, 1980). The soil texture of the the present study in all stands was clay. it indicates that changes in soil texture requires more time, while chemical properties have shown significant differences among different stands; i.e. chemical ch anges ocuure more rapid than physical change.

Characterized by the abundance and biomass of earthworms

The low abundance and biomass of earthworms in spruce stand can be due to high acidity, C/N ratio, and organic carbon in the spruce soil, while and high abundance and biomass of earthworms in alder stand are resulted from low C/N and organic carbon. Most species of earthworms play an important role on mineralization, soil structure, and constant of soil pH in 6-7 (Rashid et al., 2014). Brinkley (1994) concluded that the abundance of earthworms in pine and spruce stands was less than that in hardwood species. Lower C/N ratio makes small population size and biomass of earthworms (Rahmani and Saleh-Rastin, 2000). Nanoosi et al. (2008) found a significant and negative correlation between the abundance of earthworms and organic carbon. Moreover, Jalilvand and Kooch (2012) recorded that earthworm abundance and biomass had a strong relationship with N, C, and C/N ratio. Neirynck et al. (2000) showed that a low ratio of C/N in maple stand resulted in an increase of the earthworm population. Irannejad and Rahmani (2009) obtained a negative correlation between the density of the dry weight of earthworms and the soil bulk density. The research shows that the lowest bulk density of soil and the highest aboundence of earthworms belong to alder stand and also the high aboundence of earthworms in alder stand is attributed to low bulk density of the soil. Plantation by hardwoods and conifers affects physical and chemical properties of soil and thereby leads to significant changes in the abundance and biomass of earthworms. Therefore, choosing the appropriate species for plantation needs a comperhensive study about the soil properties and the species demands. According to findings of the present study, alder will be suggested as a suitable species for planattion, because it can increase soil fertility and the aboundence of earthworms.

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