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Investigation on Silvicultural Properties and Soil Characteristics of *Juniperus excelsa* M. Bieb in the Southeast of Iran

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Abstract: In this research, vegetative properties of *Juniperus excelsa* in relation with soil characteristics and physiographic factors were investigated in Galoochar Juniper Forest Reservoir in the southeast of Iran. First, land units maps were produced by overlaying the layers of slope, elevation and geographical aspects in GIS environment. Inventory of vegetative characteristics such as density, basal area, height, canopy cover (%), were performed in each land units by measuring at least 3 sample plots of (40×40) 1600 m^2. Three soil samples were taken from each land unit from 0-30 cm depth, then physical and chemical soil characteristic such as $CaCo_3$ %, pH, EC, soil structure (silt, clay and sand percentage) and bulk density were measured in laboratory. Based on the results the measured vegetative characteristics showed significant differences among the land units at significant levels of ($P<0.01$) and ($P<0.05$). There were significant positive correlations between number of juniper trees, basal area and canopy cover with $CaCo_3$ content and bulk density of the soils. The highest significant positive correlation was observed for $CaCo_3$ content and the canopy cover. Generally, the vegetative characteristics of *Juniperus excelsa* in the study area had significant correlation with soil and physiographic characteristics.

Key words: *Juniperus excelsa* · Vegetative characteristics · Land unit · Topographic factor · Soil

INTRODUCTION

Juniperus excelsa M.Bieb species (Cupressaceae) grows in different parts of the world; naturally it exists in Anatolia, central and south Balkans, Crimea, central and southwest Asia and east Africa [1-3]. *J. excelsa* is one of the woody trees which have special significance in local people living for making their tools, home, food and for fuel production [4]. *Juniperus polycarpus* C. Koch (*J. excelsa* M.Bieb) is an important endangered conifer tree species in inner arid region of the western-Himalayas which native people regarded it as a sacred tree [4]. They are important food sources for wildlife, several bird species feed on juniperus cones [5]. *J. excelsa* is an evergreen tall shrub or tall tree up to 20 m, with a trunk as large as 2 m in diameter (at DBH level) [6]. Their vital needs are limited. They can live in harsh environmental conditions like rocky coasts, mountain place, dry and poor soils [7], stressed and acid environments where other plants cannot grow normally [8] because of their morpho-physiological properties. In Greece *J. excelsa* habitat is mainly on stony or rocky calcareous or non-calcareous slopes [9]. Juniper root system is deep and well developed, so this species regards as an important species for consolidation soil and preventing soil erosion [10] that happens in affected by wind and rain falls [3]. The elevation that this species can grow has a reveres relation with latitude and it can differ from lowland at sea level till 3600 m in alpine mountain [11]. Topography, hydrology, soil characteristics and climate conditions have high effect on growth of *J. excelsa* [12]. By considering the importance of juniper in soil protecting and increasing biodiversity, obtaining quantitative information about site, soil factors and silvicultural properties of *J. excelsa* in natural forests is essential for their monitoring and management. By considering the importance of *J. excelsa* in preventing soil erosion and its role in protection of plants and animals living. Studying about ecological conditions of this species is very essential for better management in juniper natural forests.

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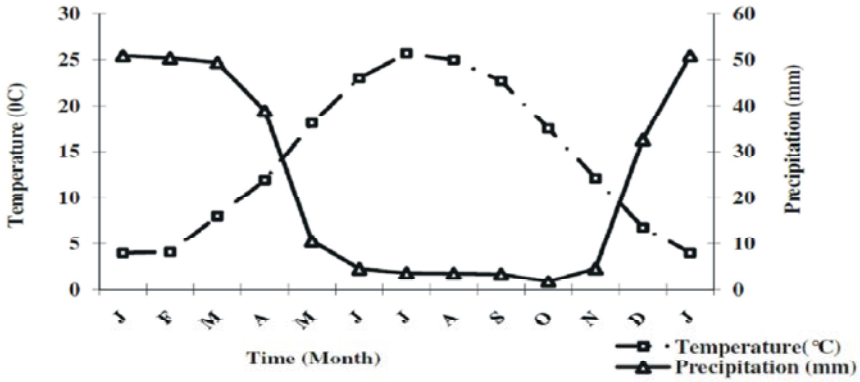

Fig. 1: Average monthly temperature and precipitation (Climatogram) in Rabor city (1990-2010)

Table 1: Topographic characteristics of land units in Galoochar Juniper Forest Reservoir

Land unit number	Elevation classes (m)	Slope classes (%)	Geographic aspect
1	2400-2600	0-20	West
3	2400-2600	0-20	East
4	2400-2600	0-20	Southeast
5	2400-2600	0-20	South
7	2600-2800	0-20	Without aspect
8	2600-2800	0-20	East
11	2600-2800	0-20	South
19	2600-2800	20-40	Northwest
20	2600-2800	20-40	Northeast

Galoochar Juniper Forest Reservoir is a protected area in southeast of Iran that ecological investigation in this area is very rarely.

MATERIALS AND METHODS

Study Area: Galoochar Juniper forest reservoir with 382 hectare area which is situated between Rabor and Sardoiye in Kerman province (South-east of Iran). This area is between latitude 29° 18' to 29° 17' N and longitude of 56° 07' to 56° 04' E. The climate is cold and it is characterized by 400 mm/y rainfall. The status of average monthly precipitation (cm) and temperature (^{0}C) of study area during a period of 20 years (1990-2010) showed in climatogram (Figure 1).

Some species like *Acer monspessulanum L. subsp. Persicum* (Pojark.) Rechf., *Pistacia atlantica* Desf. Subsp. *Mutica* (Fisch.and C. A. Mey) Rechf, *Pistacia khinjuk* Stocks., *Berberis integerrima* Bunge., *Elaeagnus angustifolia* L., *Amygdalus eburnea* Spach. and *Rosa beggeriana* Schrenk ex Fisch. and C. A. Mey. exist with *J. excelsa* in this forest reservoir.

Methods: Using digital topography data in scale of 1:25000 and Digital Elevation Models (DEM); the aspect geographic classes (E, SE, S, NE, NW, P, W), slope classes (0-20%, 20-40%) and elevation classes (2400-2600, 2600- 2800) m a.s.l layers were created in Geographic Information System (GIS) environment then these layers were overlaid and a land units map was prepared (Table 1). Each of these units was different from the other units at least in one character (slope, elevation and geographic aspect) [13].

In each land unit three (40×40m) plots were selected based on simple random sampling method [14]. In each plots measured some parameters including density, basal area, height, canopy cover (%) and canopy diameter. Three composited soil samples, 0-30 cm depth taken from each plot in each land unit, then dried and passed through a 2 mm sieve [15]. Percentage of sand, silt and clay were determined [16]. Electric Conductivity (EC), pH, bulk density and amount of $CaCO_3$ were investigated [17]. For comparing *J. excelsa* vegetative characteristics in land units and surveying correlation between vegetative characteristics and soil factors, one way ANOVA and then LSD analysis and Pearson correlation used in SPSS software environment.

RESULTS

The results of *J. excelsa* vegetative characteristics showed that the most *J. excelsa* density was in land unit number 1 with 102 (N/Hec) and the least *J. excelsa* density were in land units number 19 and 20 with 65

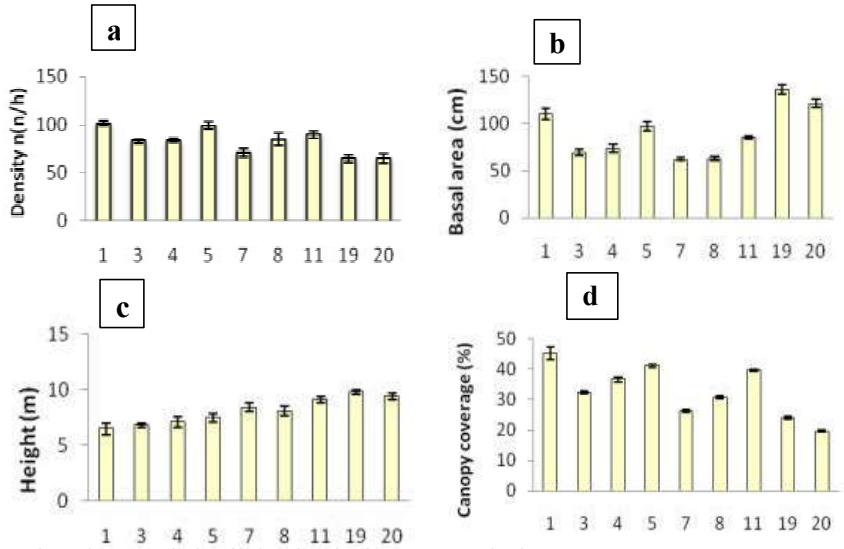

Fig. 2: J. excelsa vegatative characteristics in land units by LSD analysis

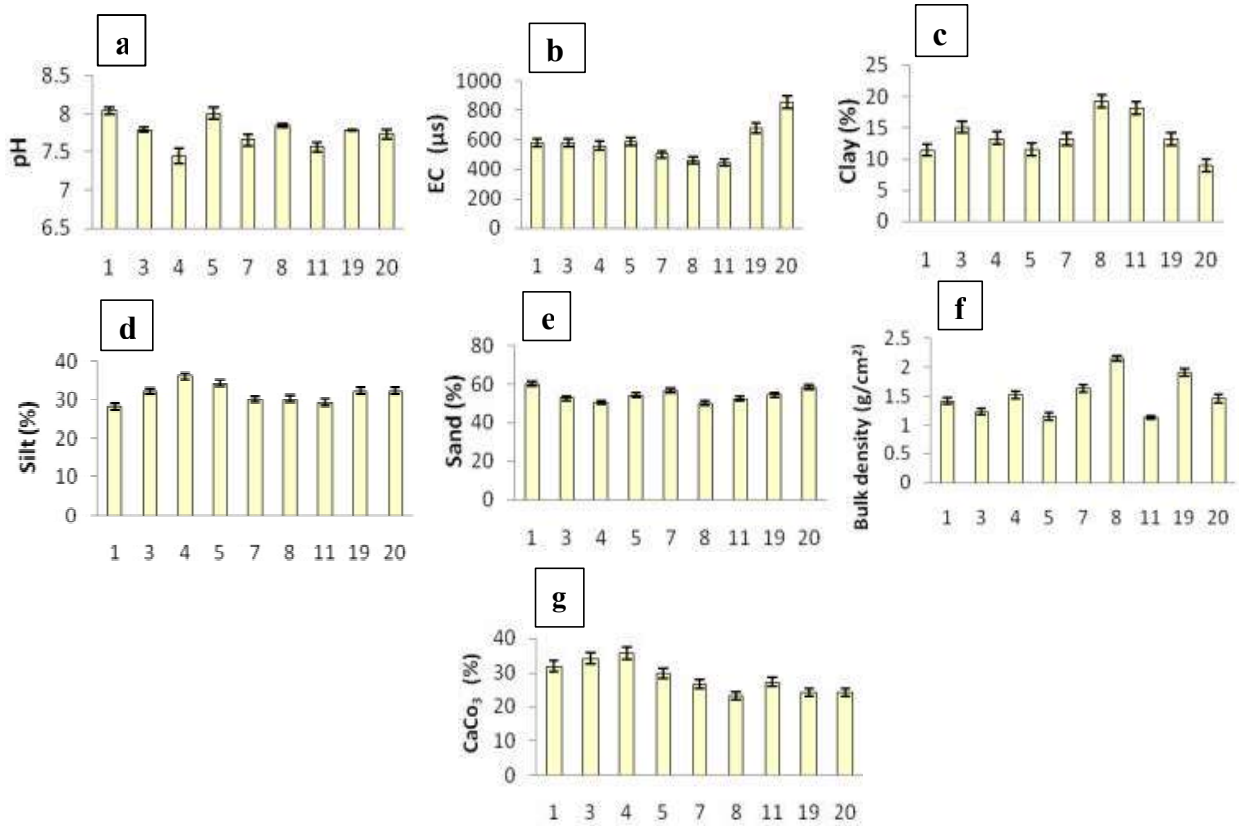

Fig 3: Comparing means of soil factors in land units by LSD analysis

(N/Hec)According to density results, this forest regards as thin juniper forest(Fig 1.a). The most and the least *J. excelsa* basal area were in land units number 19 and 8 with 136 and 63 cm respectively (Fig 1.b). The most and the least J. *excelsa* height were in land units number 19 and 1with 9.8 and 6.5 m respectively (Fig 1.c). The most and the least *J. excelsa* canopy coverage were in land units number 1 and 20 with 45.3% and 19.6% respectively (Fig 1.d).

The results of soil characteristics showed that the soil type of study area is weak alkaline. The highest and lowest pH were in land units number 1 and 4 with 8.04 and

Table 2: soil texture in land units of Galoochar Juniper Forest Reservoir

Land unit number	Soil texture	Land unit number	Soil texture
1	Loam-sandy	8	Loamy
3	Loam-sandy	11	Loam-sandy
4	Loamy	19	Loam-sandy
5	Loam-sandy	20	Loam-sandy
7	Loam-sandy		

Table 3: Pearson correlation between soil factors and J. excelsa vegetative characteristics in Galoochar Juniper Forest Reservoir (** Correlation is significant in 0.01 level (2-tailed) and * Correlation is significant in 0.05 level (2-tailed).

		Density	Basal area	Elevation	Canopy coverage	pH	EC	Sand (%)	Clay(%)	Silt (%)	Bulk density
Density	Pearson Correlation	1									
	Sig. (2-tailed)	.									
Basal area	Pearson Correlation	-.222	1								
	Sig. (2-tailed)	.265	.								
Elevation	Pearson Correlation	-.537(**)	.435(*)	1							
	Sig. (2-tailed)	.004	.023	.							
Canopy coverage	Pearson Correlation	.872(**)	-.189	-.625(**)	1						
	Sig. (2-tailed)	.000	.345	.000	.						
pH	Pearson Correlation	.395(*)	.289	-.288	.234	1					
	Sig. (2-tailed)	.041	.144	.145	.240	.					
EC	Pearson Correlation	-.452(*)	.716(**)	.297	-.543(**)	.132	1				
	Sig. (2-tailed)	.018	.000	.132	.003	.513	.				
Sand (%)	Pearson Correlation	-.049	.516(**)	.050	-.066	.368	.500(**)	1			
	Sig. (2-tailed)	.807	.006	.803	.744	.059	.008	.			
Clay(%)	Pearson Correlation	.165	-.567(**)	.029	.176	-.217	-.788(**)	-.714(**)	1		
	Sig. (2-tailed)	.410	.002	.885	.380	.278	.000	.000	.		
Silt (%)	Pearson Correlation	-.133	.021	-.088	-.116	-.269	.316	-.420(*)	-.308	1	
	Sig. (2-tailed)	.507	.917	.664	.565	.175	.108	.029	.118	.	
Bulk density	Pearson Correlation	-.385(*)	.002	.267	-.482(*)	.048	-.025	-.191	.271	-.095	1
	Sig. (2-tailed)	.048	.993	.178	.011	.814	.902	.340	.171	.639	.
$CaCo_3$	Pearson Correlation	.440(*)	-.291	-.746(**)	.590(**)	-.117	-.175	-.130	-.141	.398(*)	-.535(**)
	Sig. (2-tailed)	.022	.141	.000	.001	.561	.383	.518	.482	.040	.004

7.49 respectively (Fig 2.a). The highest and the lowest EC were in land units number 20 and 11 with 851 and 441 µm/m respectively (Fig 2.b). The soil texture in land units differed. Soil texture in land units number 4 and 8 were loam, but in other land units were loam-sandy (Table 2). The highest and lowest clay percentages were in land units number 8 and 20 with 19.22% and 9.02% respectively (Fig 2.c). The highest and lowest silt percentages were in land units number 4 and 1 with 36.21% and 28.31% respectively (Fig 2.d). The highest and lowest sand percentages were in land units number 1 and 4 and with 60.18% and 50.48% respectively (Fig 2.e). The highest and lowest bulk density were in land units number 8 and 11 equal to 2.15 and 1.13 g/cm^2 respectively (Fig 2.f).The highest and lowest $CaCO_3$ percentage were in land units number 4 and 8 with 35.37% and 23.25% respectively (Fig 2.g). The results showed that there are significant correlation between soil factors and *J. excelsa* vegetative characteristics (Table 3).

DISCUSSION

A lot of studies emphasize on high correlation between environmental factors and plant species characteristics [18] as it confirmed in present study. Among environmental factors, soil is very important [19]. Studies on relationship between plant species characteristics and environmental factors are very complicated. First, these variations are changeable very quickly; secondly, between these factors exist complicated interactions and thirdly, sometimes, observed correlations are not reliable [20]. In this research, the results showed that *J. excelsa* usually grow in loam-sandy soils. A loam-sandy soil is a light texture soil that has a high percentage of sand and low percentage of clay [21]. This species usually grow on sandy-clay, rocky and shallow soils. Therefore, the roots of *J. excelsa* can grow easily and reach to enough water in deep layers of soil, so this species can grow in arid and semiarid regions [22]. Investigated on Juniper communities and showed that

juniper roots can distributed till 1.5-3 m in soil depth. By considering EC and pH results of the soil of the study area, the soil is classified in non-saline and weak alkaline class. Maybe non-saline and weak alkaline soil effect on *J. excelsa* growth. It seems that soil characteristics are effective in more adaptation of *J. excelsa* in harsh environmental conditions [13]. The results showed that there are positive correlations between some vegetative characteristics of *J. excelsa* and soil factors. Based on the results, basal area and density of *J. excelsa* were significantly correlated with $CaCO_3$ percentage which agrees with [23]. The study area *J. excelsa* grows on mountain slopes in more than 2200 a.s.l. which is by [24]. Baker [23] showed that geographic aspects are effective on density, canopy coverage and basal area. In present research the most and lowest density of *J. excelsa* observed in west southeast geographic aspect, respectively. The highest basal area observed in northwest aspect.

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