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# Ecological Properties of Tamarix Habitats in Sistan Plain, Iran

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**ABSTRACT** The purpose of the present research was to study the properties of natural habitats and growth status of the genus Tamarix in Miankangi, Sistan Province, South-eastern Iran. Selective sampling was used to examine the natural stands structure. Then, the one ha-rectangular sample plots were established in the stands and surrounding bare lands as control plots. Quantitative variables of stands viz. collar diameter, total height, canopy surface and density in the plots were recorded. In each plot, the soil sampling was carried out from 0-30 and 31-60 cm depths, and some physicochemical parameters of the soil including soil texture, pH, EC, SP, OC, total N, available P, K, Na, Ca and Mg were measured. Data were analyzed using one-way ANOVA. The Duncan's test was used to compare the means. The soil texture of the region was loamy-silty and clay-sandy-loamy. The soil of Tamarix habitats was saline and alkaline. The results showed that the growth variables were different among the habitats. In addition, the soil clay and silt, pH, potassium and sodium absorption ratio (SAR) were significantly different among the habitats and the control. Correlation between vegetation and soil properties also showed that the diameter of Tamarix trees had positively correlated with the soil SP at also the first depth and with the clay variable at the second depth.

**Key words**: *Autecology, Drylands, Environmental factors*

## 1 INTRODUCTION

The vast territory of Iran with various climates and different properties of soil is the habitat of many species which the cost and waste of time in the restoration programs can be reduced, if factors influencing their growth and compatibility are identified. For this purpose, it is necessary to identify the relations of native plants in the area and factors influencing their establishment and survival. Environmental factors play an important role in determining habitat of plants (Escudero *et al.*, 2000; Ebrahimi *et al.*, 2015).

Studies that are conducted on the relationship between vegetation and arid and semi-arid areas are very important, because awareness of the ecological needs of different plant species plays an important role in vegetation modification and restoration plans. On the other hand, features of plant population and community are determined through their reaction to environmental conditions (Chen and Zhao, 2015). Due to the important role of plants in ecosystem equilibrium and different direct

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and exploitation of natural ecosystems by human, it is necessary to identify the relationships between plants and environmental factors, especially soil (Hasani and Sinaki, 2011; Ghazavi and Vali, 2013).

Tamarix is a tree or shrub genus with various leaves with different pods. It has 23 species generally and about 10 species of them are distributed in the south-eastern Iran (Arianmanesh *et al.*, 2015). The genus Tamarix is a plant with high longevity that can resist in different adverse environmental conditions, including high temperature, soil salinity and drought. This plant resistances in saline soil via excretion of excess salt in the soil by the leaves (Ghorbanli *et al.*, 2015). Tamarix is known as a factor for controlling the erosion, a windbreaker and a traditional herb (Xia *et al.*, 2015). Analysis of biological and environmental properties of Tamarix species shows their large compatibility with different conditions and resistance to environmental stresses (Ghorbanli *et al.*, 2015). They are also able to grow in saline soils and resist drought and high temperature, so that they can be considered as the dominant species in arid and semiarid areas (Daoyuan *et al.*, 2002; Zarea Chahooki, 2006; Willard *et al.*, 2009; Yin *et al.*, 2010; Ohrtman *et al.*, 2012; Xia *et al.*, 2015). Today, more attention is paid to this species for eliminating desertification, stabilizing sands, restoring and dynamizing the fragile ecosystem of deserts due to the problems from desertification. The success to implement plans of stabilization and restoration of deserts using this species is dependent on identifying the relation between soil and vegetation (Ardakani *et al.*, 2011). In Iran, this plant grows in Azarbaijan Province around Urmia Lake, Isfahan near Gavkhooni Wetland, Kerman Province near Sirch Mountain and also in Sistan and Baluchestan Province, near Sistan Plain and around Zahedan City. In central parts and deserts of Iran, Tamarix species can be seen. Since no information is reported about biometry of Tamarix trees and ecological features of its habitats in Sistan Plain, the purpose of the study is to identify the ecological factors of Tamarix habitats in this arid region area of Iran. Therefore, this research is to answer the following question: which traits of soil have the highest effect on Tamarix distribution?

## 2 MATERIALS AND METHODS

### 2.1 Study Area

The region of the study is located in Miankangi region, Sistan Plain. Its geographical coordinates are 61° 37' 34" - 61° 43' 56" E-Lon. and 30° 59' 5" 31° 17' 23" latitude-Lan. (Figure 1). Its climate is super-arid in Dumbarton climate classification system with the aridity index of 1.9. Its average annual rainfall is 59.6 mm and its annual evaporation is 4820.54 mmand its average annual temperature is 22°C according to the long term data. The field of study includes lowlands, alluvial plains and floodplains. Geologically, the region of the study is in Nehbandan-Khash Zone, including the geological formations from Precambrian to Quaternary. The field of study includes lowlands, alluvial plains and floodplains (Anonymous, 1995).

The region of the study is located in Hirmand river delta and its altitude changes slightly. So, climatically, it is a homogenous region and does not largely differ from Sistan Plain. In other words, in Sistan Plain, the highest frequency from the sea level ranges from 460 to 480 m and it has a hot and dry climate. Hamoon Lake is currently dry and it has created more severe dusts from the lake bed by Sistan 120-day winds (Sargazi, 2005).

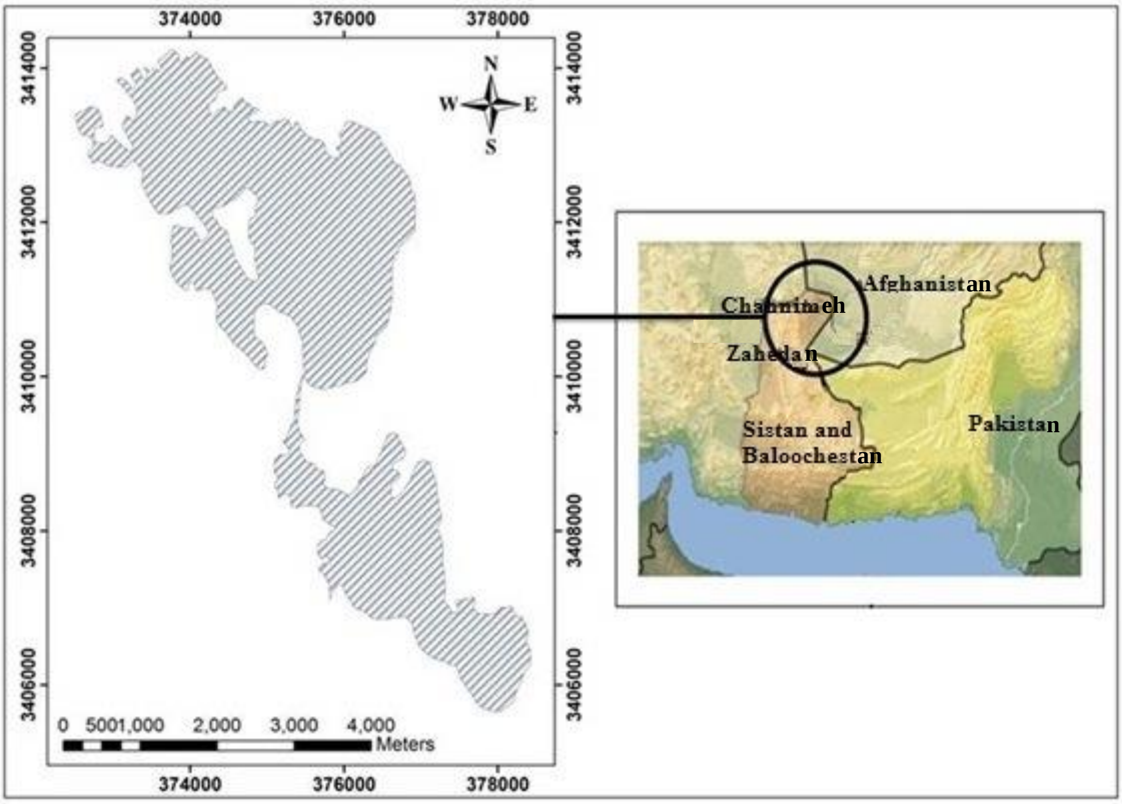


**Figure 1** The location of study area in south-eastern Iran

According to American classification system, soils of the region are in Entisols class and flurents and orthents subclasses (Anonymous, 1995). Recent droughts for several years have prevented the use of farmlands and other lands of the region also lack vegetation that increases wind erosion, and the need of the region to be protected by plant species is increased, such as Tamarix. Important species of the region include *Tamarix spp.*, *Alhaji sp.* and *Salsola sp*. Two genera of Tamarix and Haloxylon are used to stabilize sands due to their higher compatibility. The main part of plant species of the region is related to Gramineae and Chenopodiaceae families (Sobhkhyzi *et al.*, 2006).

## 2.2 Data collection

Selective sampling was used to examine the structure of Tamarix natural stands in this research. The stands were first identified using field tripping, so that five natural habitats of the genus were selected in the region as follows: Margan, Barahoei, Qorqori, Gamshad and Shandol. Within each habitat, a one ha-rectangular sample plot was selected and quantitative parameters (collar diameter, height, canopy and density) were measured (Zobeiri, 2007).

Within each sample plot, five samples were taken from each habitat and the soil sampling was carried out from any control sample near the habitats (bare land) to the depths of 0-30 and 31-60 cm, and then, it was transferred to the laboratory.

The air-dried soil samples were sieved (through a two mm-sieve) prior to chemical analyses. Soil texture was obtained by the Bouyoucos hydrometer method (Bouyoucos,





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1962). pH was determined using an Orion Ionalyzer Model 901 pH meter in a 1: 2.5 mixture of soil: deionized water (Thomas, 1996). EC (electrical conductivity) was determined using an Orion Ionalyzer Model 901 EC meter in a 1:2.5 soil:water solution (Rhoades, 1996). Soil organic carbon was measured with the Walkley-Black method (Nelson and Sommers, 1996). Total Nitrogen was measured using a semi micro- Kjeldhal technique (Bremner, 1996). Available P was determined with spectrophotometer by using Olsen method (Homer and Pratt, 1961). Available K, Na, Ca and Mg (by ammonium acetate extraction at pH 9) were determined with Atomic absorption Spectrophotometer (Bower *et al.*, 1952). Saturation percentage (SP) of the soil was directly obtained using a balance and by dividing the mass of soil water by dry soil mass (Zarinkafsh, 1993). Sodium absorption ratio (SAR) was obtained using the following equation (1):

$$SAR=Na/((Ca+Mg)/2)^{0.5} \qquad (1)$$

## 2.3 Data Analysis

Normality of variables was checked by Kolmogorov-Smirnov test. Levene's test was used to test for equality of variances. Duncan's test was used to compare the means. Soil parameters were analyzed using one-way ANOVA. Pearson coefficient and regression were used to examine the correlation between soil and vegetation properties. SPSS 16 Software was used to perform all statistical tests.

# 3 RESULTS

## 3.1 Growth Properties of Trees

According to the measurements of growth properties of Tamarix trees performed in these habitats, the results indicated that except height, all growth parameters are significantly different among different habitats. The maximum height of Tamarix trees was 2.2 m in this region (Table 1).

The collar diameter of the stem with the highest diameter was different among the habitats, with the minimum diameter belonging to Margan Habitat (6 cm) and Barahoei Habitat (7.5 cm), and the maximum diameter belonging to Qorqori Habitat (13.4 cm). The maximum canopy was observed in Margan Habitat (43%) and the minimum canopy was observed in Qorqori Habitat (14.5%) (Table 1). The density of Tamarix trees was different in this research. Since *Tamarix spp.* are observed as shrubs and coppices in these habitats than tree forms with many branches from the ground level, the density of individuals of the genus is high, so that the maximum density was observed in Margan (1080 individuals $ha^{-1}$) and Barahoei Habitats (969.5 individuals $ha^{-1}$), and the minimum density was also observed in Qorqori Habitat (115 individuals $ha^{-1}$) (Table 1).

## 3.2 Soil Physicochemical Properties

The comparison of the mean parameters of the soil is presented in Table 2. The soil texture of the habitats is mainly loamy-silty and clay-sandy-loamy. The mean clay is not significant at the first depth of the soil, but at the second depth, the property is in Gamshad Habitat (34%) more than that in Barahoei Habitat (13%). The mean silt is not also statistically significant at the first depth, but at the second depth, it is maximum in Barahoei Habitat (72%) and is minimum in Margan Habitat (35%). The mean sand is not also significantly different at the first depth, but at the second depth, it is the highest amount in Margan Habitat (48%).

**Table 1** Mean of biometric parameters of Tamarix shrubs (standard error) in Sistan Plain, Iran

| Habitat / Growth parameters | Margan | Barahoee | Gamshad | Qorqori | Shandol | ANOVA |
|---|---|---|---|---|---|---|
| Height (m) | 1.30 (0.42) | 1.35 (0.49) | 1.75 (0.35) | 1.85 (0.49 | 1.75 (0.35) | ns |
| Collar diameter (cm) | 6.0 $^{c}$ (0.16) | 7.5 $^{c}$ (0.21) | 12.0 $^{ab}$ (0.33) | 13.4 $^{a}$ (0.37) | 10.5 $^{b}$ (0.29) | ** |
| Canopy (%) | 43.00 $^{a}$ (1.21) | 22.00 $^{b}$ (0.62) | 19.60 $^{bc}$ (0.55) | 14.86 $^{c}$ (0.92) | 18.50 $^{bc}$ (0.52) | ** |
| Density | 1079.5 $^{a}$ (30.4) | 969.5 $^{a}$ (27.5) | 124.5 $^{bc}$ (3.5) | 115.0 $^{c}$ (18.2) | 235.0 $^{b}$ (7.1) | ** |

ns denotes non-significant difference and ** denotes P<0.01. Mean values with the same letter within the habitats do not differ significantly with each other.

**Table 2** Soil properties in Tamarix sites and control plots in two soil depths

| Soil properties | Depth (cm) | Habitat | | | | | | ANOVA |
|---|---|---|---|---|---|---|---|---|
| | | Margan | Barahoei | Gamshad | Qorqori | Shandol | Control | |
| Clay (%) | 0-30 | 19.0 | 11.0 | 32.0 | 27.0 | 13.0 | 19.66 | ns |
| | 31-60 | 17.2 $^{ab}$ | 13.0 $^{b}$ | 34.0 $^{a}$ | 29.0 $^{ab}$ | 16.0 $^{ab}$ | 25.66 $^{ab}$ | ** |
| Silt (%) | 0-30 | 38.0 | 61.0 | 48.0 | 37.0 | 62.0 | 41.0 | ns |
| | 31-60 | 35.0 $^{c}$ | 72.0 $^{a}$ | 50.0 $^{abc}$ | 41.5 $^{bc}$ | 64.0 $^{ab}$ | 43.33 $^{bc}$ | ** |
| Sand (%) | 0-30 | 48.0 | 28.0 | 20.0 | 36.0 | 25.0 | 39.0 | ns |
| | 31-60 | 48.0 $^{a}$ | 15.0 $^{b}$ | 16.0 $^{b}$ | 30.0 $^{ab}$ | 20.0 $^{b}$ | 31.0 $^{ab}$ | * |
| SP (%) | 0-30 | 32.0 | 40.7 | 50.3 | 52.0 | 37.35 | 44.4 | ns |
| | 31-60 | 32.4 | 46.4 | 53.1 | 43.8 | 39.3 | 45.0 | ns |
| pH (1:2.5 $H_2o$) | 0-30 | 8.06 | 8.08 | 8.79 | 8.08 | 8.63 | 8.25 | ns |
| | 31-60 | 8.04 $^{b}$ | 8.14 $^{b}$ | 9.02 $^{a}$ | 8.05 | 8.67 $^{ab}$ | 8.32 $^{b}$ | * |
| EC (ds $m^{-1}$) | 0-30 | 10.60 | 4.90 | 35.35 | 12.25 | 16.80 | 12.70 | ns |
| | 31-60 | 12.35 | 8.05 | 27.60 | 12.00 | 17.20 | 7.63 | ns |
| OC (%) | 0-30 | 0.24 | 0.02 | 0.30 | 1.00 | 0.03 | 0.23 | ns |
| | 31-60 | 0.14 | 0.06 | 0.30 | 0.36 | 0.03 | 0.19 | ns |
| Available P (mg $l^{-1}$) | 0-30 | 8.50 | 12.80 | 16.30 | 11.90 | 18.70 | 13.66 | ns |
| | 31-60 | 1.9 | 9.1 | 14.8 | 7.6 | 19.7 | 9.2 | ns |
| Available K (mg $l^{-1}$) | 0-30 | 230.0 $^{ab}$ | 120.0 $^{b}$ | 468.0 $^{a}$ | 206.0 $^{ab}$ | 120.0 $^{b}$ | 206.7 $^{ab}$ | * |
| | 31-60 | 168.0 | 130.0 | 340.0 | 235.0 | 115.0 | 220.0 | ns |
| SAR | 0-30 | 27.82 $^{b}$ | 8.85 $^{b}$ | 235.84 $^{a}$ | 47.64 $^{b}$ | 45.47 $^{b}$ | 28.68 $^{b}$ | * |
| | 31-60 | 8.07 $^{b}$ | 25.79 $^{b}$ | 392.17 $^{a}$ | 31.88 $^{b}$ | 33.27 $^{b}$ | 30.82 $^{b}$ | ** |

ns denotes non- significant difference, * and ** also denote P<0.05 and P<0.01, respectively. Mean values with the same letter within the soil depth do not differ significantly with each other.





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Saturation moisture percentage (SP) of the soil of the habitats being examined did not significantly differed at both depths of the soil. The soil pH was not significantly different at the first depth, but it was maximum at the second depth in Gamshad Habitat (9.02). No significant difference was observed between the means of the parameters including EC, organic carbon and phosphorus of the soil in Tamarix habitats. The mean potassium of the soil was significantly different at the first depth, so that the property was in Gamshad Habitat (468 ppm) more than that in Barahoei and Shandol habitats (120 ppm). The results showed that the SAR calculated in different habitats was significantly different at both depths of the soil. The property was maximum in Gamshad Habitat at both depths of the soil (Table 2).

Correlation between vegetation and soil properties showed that the diameter of Tamarix trees is positively correlated with the soil SP at the first depth and the clay at the second depth. This relation also holds for vegetation density, but negatively. Canopy percentage of Tamarix trees is also negatively related to the SP at the first depth of the soil and is positively related to the clay at the second depth of the soil. The correlation coefficient did not show any significant relationship between the height of the trees and soil factors (Table 3).

**Table 3** Pearson correlation between growth and soil properties

| Vegetation property | Soil depth (cm) | EC | pH | OC | P | K | Sand | Clay | Silt | SP | SAR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| height | 0-30 | 0.39 | 0.33 | - 0.11 | - 0.21 | 0.27 | - 0.03 | 0.21 | - 0.01 | 0.08 | 0.35 |
| | 31-60 | 0.12 | 0.22 | - 0.09 | 0.22 | 0.45 | - 0.24 | 0.44 | - 0.05 | 0.20 | 0.17 |
| diameter | 0-30 | 0.40 | 0.35 | 0.45 | 0.20 | 0.29 | - 0.33 | 0.54 | - 0.01 | 0.73 * | 0.44 |
| | 31-60 | 0.31 | 0.35 | 0.42 | 0.34 | 0.47 | - 0.40 | 0.73* | - 0.09 | 0.54 | 0.42 |
| canopy | 0-30 | - 0.18 | - 0.29 | - 0.26 | - 0.27 | 0.00 | 0.51 | - 0.17 | - 0.4 | - 0.68* | - 0.21 |
| | 31-60 | - 0.15 | - 0.33 | - 0.22 | - 0.48 | - 0.16 | 0.76* | - 0.37 | - 0.46 | - 0.66* | - 0.26 |
| density | 0-30 | - 0.47 | - 0.50 | - 0.36 | - 0.27 | - 0.29 | 0.40 | - 0.51 | - 0.08 | - 0.66* | - 0.48 |
| | 31-60 | - 0.41 | - 0.51 | - 0.36 | - 0.46 | - 0.40 | 0.42 | - 0.68* | 0.04 | - 0.49 | - 0.48 |

* Correlation is significant at the 5% level (2. tailed)

## 4 DISCUSSION

In this study it was found that Tamarix different habitats have some differences in the growth variables and soil physical and chemical properties.

In Margan Habitat, density of trees was higher and they were exposed to sandstorms. These factors limited the growth of the trees (Hasani and Sinaki, 2011). In some cases, higher collar diameter is observed in Tamarix habitats, because the branches of Tamarix shrubs reproduce. In fact, the higher the distance between the branches at the growth location, the higher the collar diameter would be, and subsequently, the trees canopy would be larger (Marvi Mohajer, 2007). Canopy percentage differed based on the trees height and the density. In Margan Habitat, the higher density of trees increased the canopy. The density was different in these habitats probably due to the soil properties, seed distribution or the available moisture for seed germination and growth of seedling, because climatic and topographical factors are almost similar in the whole region.

The EC obtained in the research is high, showing that Tamarix habitats are saline lands in Sistan Plain. High transpiration and evaporation, and low rainfall and as a result, the





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accumulation of salts and litter of trees result in the accumulation of salt at the surface of the soil and hence, the lands are salinized. Due to their deep roots, Tamarix species absorb salt ions from the deep soils and transfer them to the surface of the soil through their leaves (Arndt *et al.*, 2004). This property has made this species compatible in regions with high salinity, so that it is the most successful species in the group of invasive plants (Stromberg *et al.*, 2009).

The increase in pH and EC at the soil surface is due to the transfer of salts through Tamarix species from the deep soil and their accumulation at the soil surface, and the subsequent changes make the soil surface saline and alkaline (Arazi *et al.*, 2013). No significant difference was observed between the mean parameters of EC, organic carbon and phosphorus of the soil in Tamarix habitats. Willard *et al.* (2009) reported in a research conducted in Southern Nevada that soil salts of *Tamarix aphylla* trees are more than those of other desert trees. In this region, Gamshad Habitat had the highest pH, SAR and K. Giti (1996) found that the sodium and EC in regions planted with Atriplex and Tamarix was not less than unplanted regions, and the reason was attributed to the decrease of surface evaporation and the increase of plant uptake. Zarea Chahooki (2006) examined the habitat features of some plant species of deserts in Chah Beiki region, Yazd Province, Iran. The results showed that increase of EC, rise of underground water surface, and the increase of soil texture weight resulted in the emergence of *Tamarix ramosissima*. Ardakani *et al.* (2011) reported on their study in Chah Afzal region that in the lands planted with Tamarix species, significant increase was observed in the soil carbon, carbon to nitrogen ratio, potassium, organic matter and reaction. In these lands, all measured properties of the soil of the species were higher than those of the control region.

Yin *et al.* (2010) reported in their study on Tamarix habitats in alluvial plain in Taklamakan desert, China, that the increase of soil nutrients (organic matter, phosphorus and potassium) under Tamarix canopy showed that the species can be useful for restoration of vegetation and promotion of productivity of saline lands. However, the increase in EC and pH are the negative effects of Tamarix on the soil chemical properties. Elevated soil salinity is often associated with Tamarix invasion; however, it's unclear whether soils are more saline because of Tamarix or other environmental factors (Ohrtman *et al.*, 2012). Studies are often cited for showing that Tamarix elevates soil salinity, but generally these studies simply correlate high salinity with the presence of Tamarix. Others indicate that environmental variables such as distance from the river flooding, capillary rise from the aquifer, and eolian deposition may be more influential on salt levels or that Tamarix salt contributions do not elevate soil salinity above the tolerance range of native riparian vegetation (Glenn *et al.*, 2012).

The amount of SAR is more than 13 in all habitats of this region. So, the region has an alkaline soil. In these soils, instead of calcium and magnesium, sodium is absorbed by the roots of plants. In addition, the soil texture and structure are damaged seriously. For lands with light and sandy texture, the increase in SAR decreases water infiltration in soil. The creation of lumps and soil solidification are also another consequence of the high SAR (Suarez *et al.*, 2006).

Generally, soil properties are affected by plant response to root activities and properties of the litter fallen from perennial plants under their canopy (Xia *et al.*, 2015). Distribution of the roots of plants occurs at different soil levels and the form of distribution depends on the type of plant, environmental conditions and type of soil (Moghadam, 2008). In this region, Tamarix trees have deep roots than surface roots. According to excavations around three trees, the length of roots





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is more than 2 m. Despite their extraordinary width and thickness in the region of the study, sediments in Sistan Plain pit lack water up to the depth of 500 m due to their fine texture (silt and clay). According to the wells dug in the region, it was observed that the soil moisture fluctuated in different points. So, it can be concluded that due to the lack of underground water reservoirs in the region, different soil moisture can be due to the drains of farmlands or irrigation canals or rainfall in the region.

## 5 CONCLUSION

Sistan Plain is a flat land with a hot and dry climate. Soil texture of the region is loamy-silty and clay-sandy-loamy. The soil of Tamarix habitats is saline and alkaline. It was concluded that soil factors influencing Tamarix distribution are soil EC, phosphorus, sodium and silt, and surface water resources also affect its distribution. Different values for growth parameters in habitats also depend on the soil elements and moisture. Therefore, since the genus Tamarix is more strongly related to some soil properties, the species can be established in regions with similar conditions. The results can be a remarkable help in the restoration and development of Tamarix trees in this arid area of Iran.

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# ویژگی‌های اکولوژیکی رویشگاه‌های گز در دشت سیستان، ایران

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**چکیده** این تحقیق به‌منظور مطالعه ویژگی‌های رویشگاه‌های طبیعی و هم‌چنین وضعیت رویشی جنس گز در منطقه میانکنگی سیستان واقع در جنوب شرقی ایران انجام گرفت. در این تحقیق از روش نمونه‌برداری انتخابی برای بررسی ساختار توده‌های طبیعی استفاده شد. در هر توده قطعه نمونه مستطیلی شکل به مساحت یک هکتار و یک قطعه نمونه شاهد (اراضی بایر اطراف) روی زمین انتخاب و سپس متغیرهای رویشی از قبیل قطر یقه، ارتفاع، سطح تاج پوشش و تعداد در هکتار در آن قطعات در توده محاسبه شد. در داخل هر یک از قطعات، نمونه‌برداری از خاک در دو عمق ۳۰-۰ و ۶۰-۳۱ سانتی‌متر انجام و برخی متغیرهای فیزیکی-شیمیایی خاک از جمله بافت، اسیدیته (pH)، هدایت الکتریکی (EC)، درصد رطوبت اشباع (SP)، کربن آلی (OC)، ازت کل (Total N)، فسفر (P)، پتاسیم (K)، سدیم (Na)، کلسیم (Ca) و منیزیم (Mg) خاک اندازه‌گیری شد. داده‌ها با استفاده از آنالیز واریانس یک‌طرفه (ANOVA) و آزمون Duncan مورد تجزیه و تحلیل قرار گرفتند. بافت خاک از نوع لومی سیلتی و رسی شنی لومی است. خاک این رویشگاه‌ها شور و قلیایی می‌باشد. نتایج نشان داد متغیرهای رویشی از قبیل میزان ارتفاع، سطح تاج پوشش، قطر یقه و تراکم در بین رویشگاه‌ها متفاوت بود. هم‌چنین از نظر درصد رس و سیلت، اسیدیته، پتاسیم و نسبت جذب سدیمی (SAR) خاک در بین رویشگاه‌ها و قطعات شاهد اختلاف معنی‌داری مشاهده شد. همبستگی میان متغیرهای رویشی و ویژگی‌های خاک نشان داد که قطر درختان با رطوبت اشباع خاک در عمق اول و مقدار رس در عمق دوم همبستگی مثبت دارد.

**کلمات کلیدی:** اکولوژی فردی، عوامل محیطی، مناطق خشک



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