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Distribution of *Salsola crassa* in relationship to groundwater level and soil features at dry rangelands in Iran

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Abstract
The present study was conducted to investigate the relationship between groundwater level and soil characteristics with distribution of *Salsola crassa* species in arid rangelands of Aran-o-Bidgol in Iran. The studied area was divided into three habitats: high density, low density, and absence of *Salsola crassa.* Comparison of physic-chemical characteristics of soil and groundwater level was made by using one-way ANOVA and Duncan test. The results showed that the percentage of sand, EC, pH, P, OM, and SAR in the soil in three habitat communities differed significantly. The presence of this plant species increased the amount of these attributes. Physical and chemical properties of the soil at 0-30 and 30-60 cm showed that the percentage of clay, silt, gravel, EC, pH, OM, P, K and SAR were also different at two depths of soil.

Keywords: Arid land, Groundwater, Plant density, *Salsola crassa*

The presence of a plant species is not a coincidence or accidental in the geographical area, but both climatic and edaphic conditionsdetermine plant distribution in that area (Hoseini, 2010). Today drought and salinization are growing problem worldwide, and being hit particularly hard in Iran. There are approximately 25 million hectares of saline and alkaline soils in Iran, which includes approximately 15% of the country surface (Mirdeilami *et al.,* 2012). Some of these habitats are caused by limitations, such as salinity and salty shallow groundwater that produce an unsuitable environment for growth of plants (El-Ghani and Amer, 2003; Ram and Trivedi*,* 2016). Rangeland vegetation cover is influenced by severity of environmental factors (Holechek *et al.,* 2004; Song *et al.,* 2006) and it has an important role in distribution of plant, formation, development and sustainability of plant communities.

Plant species has a close relationship with soil properties and many of them are just an indicator of one type of soil (El-Ghani and Amer, 2003; Kumawat *et al.,* 2016). Today, there are three main solutions for use and exploitation of these saline ecosystems, which include washing the salt from the soil surface, transition of salt to lower layers of the plant's root, and increasing sustainability of plants against salinity by using indigenous plants from saline areas. To tackle the problem with the salinity of the soil, the third solution, which uses the native salty plants, was tried earlier (Kooch *et al.,* 2008; Plaster, 1992; Jafari *et al.,* 2002; Motiee and McBean, 2017). Mirdeilami *et al.* (2012) studied some factors of soil and topography on the distribution of medicinal species of Maraveh tappeh at Golestan province. They found that among the soil factors, acidity and soil texture had the greatest effect on plants distribution. In another study, Heshmati (2003) studied the environmental factors affecting establishment rangeland plants in Golestan province. They showed the groundwater depth, geography and soil salinity were the most important factors affecting the segregation of plant communities. In other studies (Asrari *et al.,* 2012; Jafari *et al.,* 2006; Pei *et al.,* 2008) on salt lands in Qom province, indicated that the salinity, lime and potassium of soil played the most important role in establishing vegetation cover. In addition, some researchers (Carnival and Torres, 1990; Noy-Meir, 1973; Moiner and Adbelghani, 2000) showed that the soil salinity factor was one of the most important factors that affected the establishment of plant's community.

Abdel-Razik *et al.* (1984) reported that the most important effective features on the distribution of plant communities in saline lands, were salinity, soil texture and percentage of organic carbon in soil. Rostam Poor (2009) and Ghaderi *et al.* (2010) also suggested that the soil salinity as an effective factor on vegetation distribution. Thus the difference in percentage of plant species in different regions were due to different environmental factors, among these factors, soil salinity was found as the most important factor in relation to plant distribution. In the present investigation, the hypothesis 'whether *Salsola crassa* distribution follows this rule or is an exception' was tested. Keeping this in view, this investigation was aimed to study the relationship between groundwater level/soil properties and distribution of Salsola *crassa* in arid rangelands at Aran-o-Bidgol of Isfahan province.

The **s**tudied area was located in the north of Kashan province with longitude 51° 48' and latitude 34° 7' at an altitude of 850 m above mean sea level. It was located on the western part of Maranjab desert and south side of Qom Lake. The area was about 75,223 hectares and considered a part of arid rangelands of Aran-o-Bidgol province that used especially for feeding camel herds. Minimum altitude from the free sea level was 810 m and maximum was 880 m. The average rainfall was 110 mm and mean annual temperature was 23.5 °C.

The climate was divided in arid regions according to Dumartren categories (Hoseini, 2010). The soil of this region was saline with shallow groundwater level. Its predominant plant type was *Salsola crassa,* however, *Seidlitzia rosmarinus,* and *Halocnemum strobilaceum* were also seen in this area. *Salsola crassa* is a shrub belonging to the Chenopodiaceae family with juicy and meaty leaves and visible as convened plants. It is important to provide forage in autumn and winter season to livestock, but the highest percentage of herbal biomass was recorded during summer in rangelands. This species is not preferred by livestock, although in winter, it is used as main forage for the livestock especially camels. The studied area with dominant *Salsola crass* species was selected by using topographic maps and field survey. Grazing operation was banned in this area for 10 years and the area was divided in three parts which included high density, low density, absence of *Salsola crassa* (Hoseini, 2010).

The protected areas had high density of *Salsola crassa* (1200 plants and 90% frequency). The vicinity of this area had the less density of *Salsola crassa* and was classified as low density (500 plants and 50% frequency) habitat. The region, where *Salsola crassa* was not observed, was considered as an absence zone or control zone. To record the *Salsola crassa* density in each area, three transects with100 meters long were conducted randomly. In each transect, 10 plots of one square-meter were placed systematically. For soil sampling in a systematic method, three profiles in the beginning, middle and end of transect from two depths 0-30 and 30-60 cm within the root zone were drilled. For the groundwater sampling Walkley-Black method was followed, first hacked the hole with an auger to install the pipe, then in each areas, three pipes with 1.5 meter built according to the range of variation of groundwater level. At the beginning of each month, the groundwater level was measured and noted. Soil samples after transferring to the laboratory, were passed through 2 mm sieve. Then soil texture (Bouyoucos hydrometer method), organic carbon (Walkley-Black method), lime (Calcimeteric method), EC, percentage of total nitrogen (Kjeldahl method), absorbable phosphorus (Olsen method) and absorbable potassium, the ratio of sodium absorption, were measured (Ali Ehyai *et al.,* 1993). Comparison of physicochemical properties of soil and groundwater level in three habitat communities, which included high density, low density, and absence of *Salsola crassa* was done by means and unilateral variance analysis, and Duncan test following standard statistical methods. The interaction of depth and habitat was also measured by GLM (general linear model) test (Holechek *et al.,* 2004).

Variance analysis of physical and chemical soil properties in three habitat communities (high density, low density, absence/no presence) for two depths 0-30 and 30-60 cm and interactions between depth and habitat were conducted (Table 1). The results showed that the percentage of sand, clay and silt in the soil differed in three habitat communities (Table 1). For the two elements of phosphorus (P) and potassium (K), the difference was not significant between two habitat communities (high density and low density). But the amount of phosphorus and potassium differed ($P<0.01$) at high density and low density habitat communities compared to an area where there was absence of *S. crassa*. However, clay and silt content in three habitat communities were similar. In other words, with increasing the percentage of *S. crassa* species, all soil properties were improved except clay and silt percentage. Therefore, it was said that the plant species studied had meaningful relationship with soil characteristics like EC, pH, lime, OM, P, K, and SAR. The presence of this plant species improved these features.

The results of analysis of physical and chemical properties of the soil at 0-30 and 30-60 cm also showed that the percentage of clay, silt, gravel, EC, pH, OM, P, K and SAR differed significantly at two depths of soil. However, the soil lime content was comparable between two depths of soil (Fig 1-4). Amount of sand percentage, EC, pH, OM, P, K and SAR at depths of 30 cm were more than 60 cm depth and the percentage of clay and silt in the second depth was more than the first depth. In addition, by considering the interaction between depth and habitat, the results showed that all of the physical and chemical properties of soil with each other had a significant relation (Fig 1-4). The variance analysis and comparison the average of the groundwater level at three habitat communities were also done (Table 2; Fig 5). The results showed that the level of the groundwater differed significantly amongst three habitat communities. The level of groundwater at the high-density habitat communities was more than low density and at low density, it was higher than absence habitat.

Table 1. Comparison of physical and chemical properties of soil at two depths (0-30 and 30-60 cm) in three habitat communities

Component	SOV	df	MS	F
Clay	Habitat	2	11.23	29.70^{ns}
	Depth	1	125.02	328.42**
	H*D	2	55.18	159.58**
Silt	Habitat	2	6.40	2.14^{ns}
	Depth	1	142.6	30.07**
	H*D	2	28.15	8.01**
Sand	Habitat	2	2.03	1.30**
	Depth	1	129.52	89.23**
	H*D	2	59.19	39.08**
SAR	Habitat	2	2.13	1.62**
	Depth	1	140.02	78.13**
	H*D	2	23.50	26.05**
Lime	Habitat	2	199.06	176.22**
	Depth	1	0.015	0.15^{ns}
	H*D	2	50.08	66.13**
Organic Matter	Habitat	2	0.44	30.25**
	Depth	1	0.54	108.32**
	H*D	2	0.11	16.75**
P	Habitat	2	2.75	14.22**
	Depth	1	3.01	19.09**
	H*D	2	2.68	17.27**
K	Habitat	2	2.30	12.38**
	Depth	1	2.17	17.08**
	H*D	2	2.33	15.45**

SOV: Source of variation; MS: Mean squares

Table 2. Results of variance analysis of groundwater table in distribution of *Salsola crassa*

Component	SOV	SS	MS	F
Ground	Habitat	395.658		
water table	Error	24.759	231.68	
level	Total	521.250	12.43	38.325**

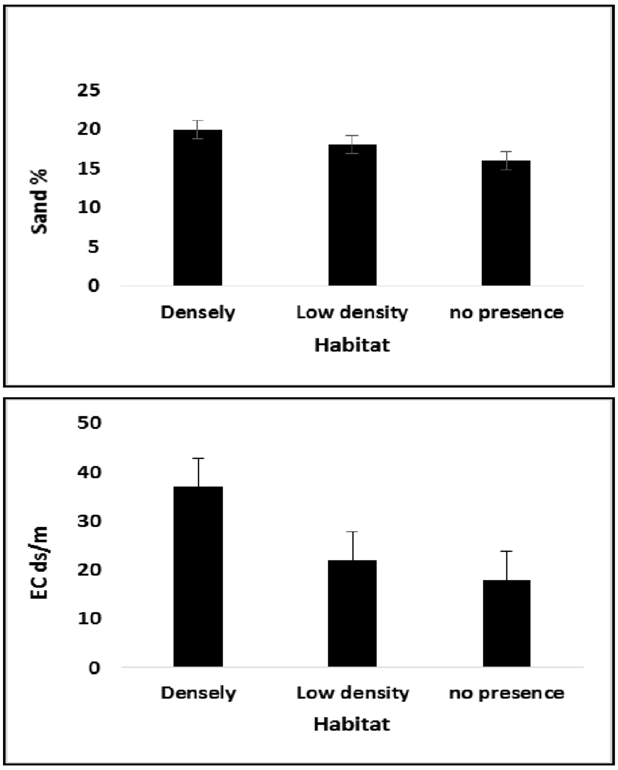

Fig 1. Mean of sand and EC content in three habitat communities

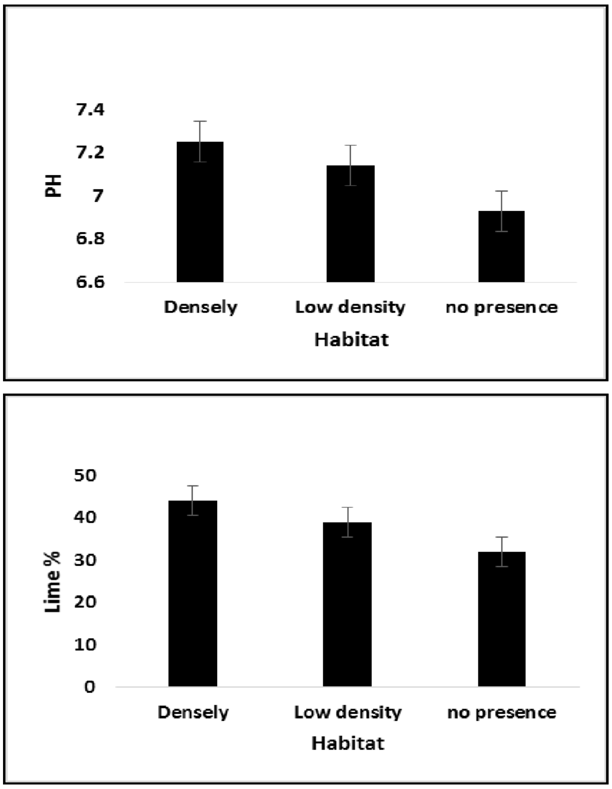

Fig 2. Mean of PH and Lime content in three habitat communities

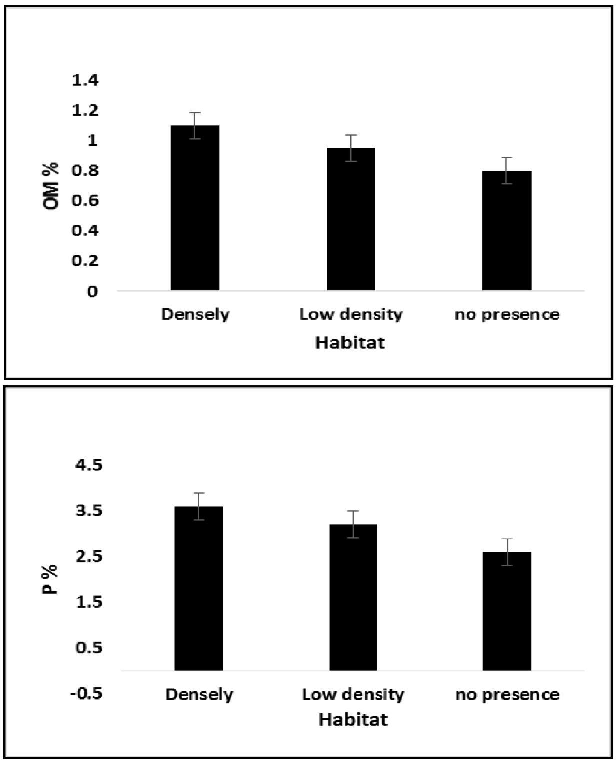

Fig 3. Mean of OM and P content in three habitat communities

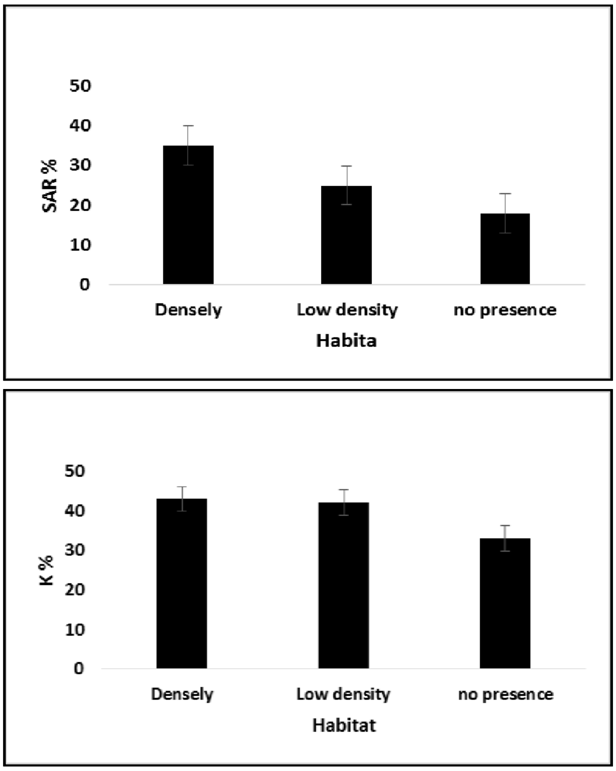

Fig 4. Mean of SAR and K content in three habitat communities

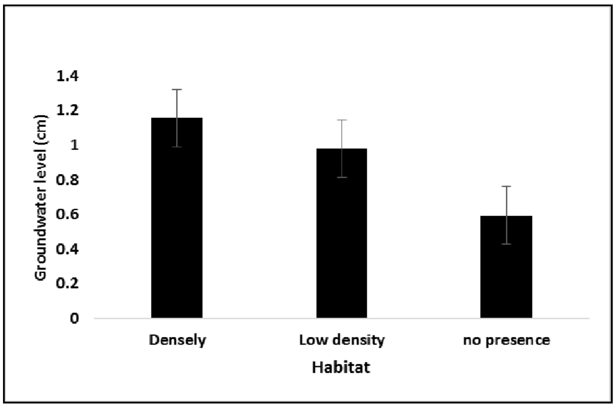

Fig 5. Mean of groundwater level in three habitat communities

It was concluded that the *S. crassa* species had noticeable effect on the amount of soil organic matter that causes to increase it. Increasing organic matter improved the physical and chemical structure of the soil, with decomposition of plant's litter and roots. Organic matter improved the soil adhesion, fertility and water absorption by the plant and mineralization of the soil. Indeed, with increased density of *S. crassa* the percentage of soil components was increased except clay and silt percentage. Thus this plant species had a significant relationship with EC, pH, lime, OM, P, K and SAR characteristics.

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