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Original article

The effects of shrubs salsola arbusculiformis Drob. on soil chemical and physical characteristics in North East rangelands of Iran

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A B S T R A C T

The purpose of this investigation was to study the effects of Salsola arbusculiformis on soil physico-chemical characteristics in rangelands of in Garmeh Located in northeast of Iran. After surveying the regions, the three sites (karnakh, Aspakho, Robat) with Salsola arbusculiformis were selected. Vegetation cover and soil parameters were sampled by a random systematic method, in each region. Five transects each 100 meter length were selected and then 50 plots by the average of 1m ×2m were randomly chosen and vegetation cover parameters such as percentage canopy cover, production, density and percentage litter were measured in the key area of each site. Soil samples were taken from two depths (0-30, 30-60 cm) under plant and in control areas. The measured characteristics of soil included texture, electrical conductivity (EC), acidity (pH), nitrogen (N), phosphorus (P), potassium (K), Sodium (Na), Organic matter(OM), $CaCO_3$ and $CaSO_4$ .Data were analyzed using SPSS software under windows. One-way ANOVA and T-test were used to compare the data related to planted and control treatments. Results showed that Salsola arbusculiformis significantly increased the amount of K, pH, EC, N, Na ($P<0.01$), and O.M ($P<0.05$). In these sites measured characteristics of soil in planted areas were more than the control ones.

1. Introduction

Knowledge of ecological factors such as climate, soil, topography and disturbance influencing plant species distribution is essential for conservation, management, and recovery of rangeland ecosystems (Ajeer & Shahmoradi, 2007; Nautiyal et al., 2009). Generally ecosystem is a unit consisting of all factors, including environmental factors and organisms in which the interaction of animate and inanimate components should be considered. However, the vast number of rangeland ecosystems and the variety of variables brings out estimating complexities of relationships and their effects. Therefore, effective relationships between plants and the environmental context can be studied under different categories. One of these items is the effect of plants on soil. Plants can be indicators of ecological conditions that show a real ecological in each region (Khedri Gharibvand, 2007). The interaction of soil-plant and morphological and physiological status of plants determines the dominant effect of plant or soil. Therefore, such environments combined together in a state of steady flow are placed in the way of activities, actions and interactions which affect and influence each other to create the change. According to studies conducted, the establishment of vegetation and its expansion causes the improvement of soil physical and chemical characteristics and facilitate natural resource management particularly rangelands. Some of environmental factors such as moisture and soil nutrients had significant effect on plant-community (Mahdavi Ardakani et al., 2010).

Plants affect physical and chemical characteristics of soil. It can be said that the food reserves in the soil properties and vegetation is highly dependent on plant spices (Barth, 1980). The soil characteristics are affected by soil response to root activity and characteristics of litter that fall under canopy collapses perennial plants (Balamurgan et al., 2000). For example, perennial plants by accumulation of litter and whose roots affect the soil quality, improve their sites (Davidson and Morton, 1984). The effect of plants on soil characteristics has been studied in Iran and other parts of the world.

Bailey (1970) believes the vegetation, will speed the nutrient cycle and created favorable changes in the microclimate of the area. Mugunga and Mugumo (2013) studied the effects of Acacia sieberiana plants on the soil chemical properties in Songa, they reported that the amounts of nitrogen, Calcium, soil organic carbon, Cation exchange capacity (CEC) and pH were higher in soils under tree canopies than open areas. Halvarson et al. (1997) in the study of sagebrush fields south of Washington concluded that the accumulation of organic carbon and nitrogen and the speed of nitrogen cycle in the soil below of Artemisia tridentate plant is more than the soil between plants.

Jafari et al., (2006) in rangelands of Qom province, Iran, studied the relationships between soil properties and plant species distribution. Their results showed that the most important factors for separation of plant types were soil texture, electrical conductivity and $CaCO_3$.

Mojiri and Jalalian (2011) results that electrical conductivity, sodium ions, HCO_3^- and the percentage of clay had negative effects on Nitraria schoberi plant physiologic parameters. Koochaki (1996) mentioned some reasons for differences in soil nutrient levels under the crown of the plant as follow: 1) nutrient uptake by plant roots shallow and deep, 2) immobilization of nutrients by plants or symbiotic organisms, 3) increased soil nutrients by large organisms that use plants to their nests and rest, etc and 4) stop and accumulate in Brushwood and soil particles caused by wind at the foot of shrubs and trees. Jahanbin et al. (2013) reported that Myrtus communis plants increased organic matter, total nitrogen, potassium, phosphorous, cupper, manganese, iron, zinc and electrical conductivity of soil. The purpose of this investigation was to study the effects of Salsola arbusculiformis on physico-chemical characteristics of soil in Robate, Aspakho and Karnakh regions in North East rangelands of Iran.

2. Materials and methods

The study area was chosen in arid rangelands of Garmeh in North East of Iran (North Khorasan Provinces). This region is situated between 37° 18' to 37° 24' North latitude and 56° 20' to 56° 37' East longitudes. The area is approximately 30000 hectares with elevation ranging from 1280 m to 1600 meter. The means of precipitation is

229mm/year that maximum and minimum of precipitation occur in April and July respectively. The mean of annual temperature is 12.9 ° C. The average maximum temperature is 32.6 ° C in July and minimum temperature is -5.92 ° C in January. The climate of this region with using of Emberger method is cold arid. The embrothermic diagram show that drought period is for six months of year and wet season start in November and continues until May.

After identifying the regions, the three sites (karnakh, Aspakho, Robat) with Salsola arbusculiformis were selected. Five transects each 100 meter length were selected and then 50 plots by the average of 1m ×2m were randomly chosen and vegetation cover parameters such as percentage canopy cover, production, density and percentage litter were measured in the key area of each site. Soil samples were taken from two depths (0-30, 30-60 cm) under plant and in control areas. Soil samples after drying and passing the 2 mm sieve to determine chemical properties included texture, electrical conductivity (EC), acidity (pH), nitrogen (N), phosphorus (P), potassium (K), Sodium (Na), Organic Carbon(OC), CaCO3 and CaSO4. Data were analyzed using SPSS software under windows. One-way ANOVA and T-test were used to compare the data related to planted and control treatments.

3. Results and discussion

3.1. Climate and Flora

Climate is one of the most important factors in the plant development (Vallejo et al., 1998). Irano-Turanian zone which fall and winters are cold, rainy and snowy, and summers are dry and hot, are covered by sclerophylleous species that need quite little water and high temperatures (Dogan et al., 2003).Using the Emberger climate classification, the habitat of Salsola arbusculiformis was categorized as cold arid. The mean annual rainfall and temperature were about 229 mm and 12.9 °C for the habitat, respectively, with the bulk of the rains concentrated in February, March, April and May.

The Flora of study area is rich composed of annual and perennial plants. This area is categorized as fair rangelands. Other plants include Artemisia sieberi, Poa bulbosa, Stipa barbata, Carex sp., Eurotia ceratoides, Salsola rigida, Bromus tectorum and Scariola orientalis.

3.2. Soil texture

The soil particles size composition of soil in the area is shown in Table 1. The physical analysis of the soils showed that Salsola arbusculiformis grows on loamy (63.34%), sandy-loam (18.33%), clayey-loam (15%) and Silt- loam (3.33%) soils. The results showed that the soil texture under the Salsola canopy hasn't changed. Soil texture has a large effect on controlling soil moisture and nutrients available to plants (Jafari et al., 2006). Among morphological parameters, soil and vegetation are closely related. Therefore, any suggestion for reform in rangeland should take into account the soil properties. Having the knowledge of soil characteristics of each species has effective role in suggesting compatible species to the soil conditions in the same areas (Jafari et al., 2006).

3.3. Acidity (pH)

The results indicated that among of Acidity in the studied sites are significantly different (Table1). In relation to the effects of Salsola arbusculiformis on soil acidity results showed that soil pH is significantly increased under Salsola canopy rather than outside it and save it under 8.93and outside the canopy 8.15units (Table 2). Soil analysis show that soil samples are moderately alkaline, according to JACKSON's (1958) soil-pH classification. The pH level of the soil surface was significantly higher than the soil depth. There was an interaction between soil depth and soil cover dressing so that with increasing the depth, shading acidity increased (Table 2). Zheng et al. (2008) whit studying Salsola passerina found that the pH with increasing depth plants did not show significant differences, but its rate savings under the canopy is 9.1 and outside the 8.45.

3.4. Electrical conductivity (EC)

Salsola arbusculiformis significantly increased the electrical conductivity. EC under Salsola canopy was 590 verses 200 µS/cm out of Salsola canopy. Ec indicate significant decreases with increasing depth (Table 2). In comparison, the interaction of different levels of electrical conductivity depth coverage on the outside of the canopy, there is no significant difference, but under different soil depths in contrast to significant savings can be seen that the electrical conductivity decreased with increasing depth (Table 1). Plants existences provide shade and reduce the temperature of the soil surface evaporation, less water and less solute transfer from the surface to depth, while the organic acids resulting from the decomposition of organic material dissolved minerals and helps release ions (Titus et al., 2002). Falah Shojaee (2006) in the study of four Acacia species concluded that the electrical conductivity of soil in Acacia canopy shading were significantly higher than out plants and they express that most of activity of micro-organism in shading due to higher food region, leading to increased secretion of organic acids in the root zone, which is an increase of ions causes an increase in electrical conductivity. Results Everett et al. (1986) showed that the electrical conductivity of the soil-plant pine trees out there and also shading and gradual decrease of the electrical conductivity decreased with depth. McDaniel and Graham (1992) indicate that electrical conductivity beneath the canopy and outside canopy of pine has a significant positive correlation with increasing depth. Zheng et al. (2008) found that the rate of Salsola passerina rangeland plant canopy under increased electrical conductivity and the electrical conductivity decreases dramatically with increasing depth.

Table 1
The analysis results of soil in the habitats of Salsola arbusculiformis.

Soil properties		**Region**					
		Robate		**Aspakho**		**Karnakh**	
	Soil depth (cm)	**under canopy**	**outside canopy**	**under canopy**	**outside canopy**	**under canopy**	**outside canopy**
EC (µS/cm)	0-30	546a	177b	698a	206b	522a	213b
	30-60	549a	305b	420a	179b	509a	157b
PH	0-30	8.764b	8.19c	9.15a	8.122c	8.864b	8.134c
	30-60	8.204b	8.072b	8.784a	8.128b	8.6ac	8.23cb
saturation	0-30	52.968a	45.21a	52.418a	47.71a	44.712a	45.966a
moisture %	30-60	59.046a	49.442a	51.72a	51.682a	48.712a	43.61a
$CaCO_3$%	0-30	25.37a	21.92a	26.385a	24.25a	24.13a	23.075a
	30-60	22.845a	22.795a	24.27a	25.305a	21.587a	25.505a
$CaSO_4$%	0-30	0.886a	0.878a	0.883a	0.879a	0.887a	0.884a
	30-60	0.893a	0.879a	0.886a	0.878a	0.892a	0.880a
OC%	0-30	1.33a	1.13ab	1.37a	1.19a	0.94ab	0.66b
	30-60	0.94a	0.697a	1.04a	0.631a	0.53a	0.482a
N%	0-30	0.0284a	0.0293a	0.0297a	0.0241bc	0.0255b	0.0227c
	30-60	0.0242a	0.0239a	0.0227a	0.0205bc	0.0216ab	0.0194c
K(mg/kg)	0-30	81.643a	40.46d	101.37b	40.155d	58.903c	40.884d
	30-60	31.656bc	20b	65.53a	25.093b	41.468c	28.42bc
P(mg/kg)	0-30	0.052a	0.123a	0.079a	0.78a	0.136a	0.171a
	30-60	0.064a	0.074a	0.06a	0.082a	0.05a	0.03a
Na(mg/kg)	0-30	67.02a	4.74b	52.95ac	5.63b	40.16c	8.40b
	30-60	76.30a	20.52b	73.95a	5.92b	52.50a	4.23b
Clay (%)	0-30	10.35	10.28	10.47	13.14	12.38	14.31
	30-60	25.74	23.65	26.47	19.37	23.65	24.04
Silt (%)	0-30	38.93	41	30.81	37.74	39	31.6
	30-60	37.94	36.03	40.01	34.71	41.73	37.84
Sand (%)	0-30	50.72	48.72	58.72	49.12	48.62	54.12
	30-60	36.32	40.32	33.52	45.92	34.62	38.12

Note: Values with unlike letter in a row are significantly different at 0.05 levels.

3.5. Organic carbon

The results showed that among of Organic carbon in the studied habitats are significantly different (Table1). Salsola arbusculiformis significantly increased soil organic carbon under the plant canopy (Table 2). So that out of the shadows is 0.79% and savings under 1.03%. Organic carbon in the soil surface is higher than the lower layers. Mlambo et al. (2005) in South Africa to study Colophosprmum mopane plant amount of organic carbon in the canopy obtained from zero to 10 cm depth was significantly higher than that obtained from shading. The increase in organic carbon can be attributed to various processes such as accumulation of litter (Zinke, 1962), reducing in erosion or increase in sedimentation (Charley, 1977), improve micro-climatic soil conditions (Pierson and Wight, 1991) or be input sources such as insects, birds and other animals (Davenport et al., 1996). In general, the amount of organic matter accumulated Litter plant size and there is a direct relationship (Titus et al., 2002).

3.6. Nitrogen (N)

Salsola arbusculiformis has a significant impact on canopy soil nitrogen. As can be seen in Table 2, the amount of soil nitrogen was higher under Salsola canopy. Nitrogen levels in the canopy soil and the outside canopy soil was 0.03 and 0.025 %. This difference significantly different between the depth can be seen in the surface soil nitrogen grenades in the verse above (Table 1). The contrasts between the different depths and soil cover have difference significant, and the effect on Common Myrtle plant phosphorus in the soil indicates (Table 2).

3.7. Potassium (K)

The results showed that among of Potassium in the studied habitats are significantly different (Table1). In this study, soil K under Salsola canopy was significantly higher (80.64 mg kg-1) than outside the canopy (40.5mg per kg). This increase can also be seen at various depths in the soil (Table 2). Mishra et al. (2003) showed a significant difference in soil K between the canopy and outside canopy of 3 and 6 years old eucalyptus trees. The reason for this increasing could be due to releasing potassium from K-bearing minerals and causes significant increase in K under the canopy of K release or litter decomposition relationships. Banerjee (1986) with the ecosystem studying of which it was the dominant oak species, expressed as the amount of exchangeable potassium in the canopy than outside the shading. Karimian and Razmi, (1990) causes an increase in the concentration of potassium in the plant canopy organic matter in the plant shading savings and increased biochemical activity and results in the release of potassium-bearing minerals potassium. Wang et al. (2000) described an increase of organic acids secreted by plant roots leads to release of potassium by plants contain minerals such as potassium feldspar gneiss and is. Tan (1978) effect of organic compounds on Humic acid and Folic acid and K release from illite and smectite clays showed.

3.8. Phosphorus (P)

There was no significant difference ($P>0.05$) in the soil Phosphorus between the control and under the canopy soil. However, Phosphorus ranges were between 0.02 and 0.09 mg/kg. The average value for soil P is between 0.0006 and 0.0009% (Eskin et al., 2013). The results showed that soil P for three locations is low.

3.9. Sodium (Na)

The results indicated that among of Na in the studied sites are significantly different (Table1). Salsola arbusculiformis significantly increased the amount of sodium ions under the plant canopy than outside the canopy (Table 2). Soil sodium increases soil reaction, encourages low uptake in some types of micronutrients and destroys the physical properties of soils, thereby reducing soil permeability and growth of plants (Honarjoo et al., 2010).

3.10. The Percentage of Calcium Carbonate ($CaCO_3$)

The soils habitats of this plant have high level lime varying between 14.5 to 29.15%. According to Table 2, the percentage of calcium carbonate was no significant difference ($P>0.05$) between the control and under the canopy. Soil carbonate causes the creation of appropriate soil structure and induces changes to soil acidity (Jafari et al., 2006).

3.11. The Percentage of CaSO4

There was no significant difference ($P>0.05$) in the soil $CaSO_4$ between the control and under the canopy soil. The soils habitats of this plant have very low level gypsum (Table1).

3.12. Saturation moisture percentage

Tests showed that the Salsola arbusculiformis shrubs increased saturation percentage. Saturation percentage below perspective shadows is 51.59% and out of perspective shadows is 47.26%. But it is not a significant difference between different regions and soil depths (Table 1, 2).

Table 2
The compare of physical and chemical analysis results on the soil in the habitats of Salsola arbusculiformis in 0-30 and 30-60 cm depths.

Soil properties	Treatment	Average 0-30 (cm) depth	Average 30-60 (cm) depth	SE	sig.
EC (µS/cm)	under canopy	590	490	66	ns
	outside canopy	200	210	35	ns
PH	under canopy	8.93	8.53	0.125	**
	outside canopy	8.15	8.14	0.038	ns
saturation moisture %	under canopy	50.03	53.16	2.09	ns
	outside canopy	46.29	48.24	2.38	ns
$CaCO_3$%	under canopy	25.29	22.9	1.052	ns
	outside canopy	23.08	24.54	1.02	ns
$CaSO_4$%	under canopy	0.88	0.89	0.0038	ns
	outside canopy	0.88	0.88	0.0012	ns
OC%	under canopy	1.21	0.84	0.15	*
	outside canopy	0.99	0.6	0.10	**
N%	under canopy	0.03	0.023	0.0006	**
	outside canopy	0.025	0.021	0.0004	**
K(mg/kg)	under canopy	80.64	46.22	6.48	**
	outside canopy	40.5	24.5	1.67	**
P(mg/kg)	under canopy	0.09	0.06	0.022	ns
	outside canopy	0.12	0.06	0.019	ns
Na(mg/kg)	under canopy	53.37	67.58	8.93	ns
	outside canopy	6.25	10.22	2.78	ns
Clay (%)	under canopy	11.07	25.38	1.85	**
	outside canopy	12.57	22.35	1.77	**
Silt (%)	under canopy	36.25	39.89	2.08	ns
	outside canopy	36.78	36.19	3.02	ns
Sand (%)	under canopy	52.7	34.82	3.07	**
	outside canopy	50.65	41.45	3.28	*

*Significant at 5% alpha level, **Significant at 1% alpha level.

4. Conclusion

The results show that the Salsola arbusculiformis can influence soil chemical and physical characteristics of their habitat. In this study, the shrubs increased electrical conductivity, acidity, organic carbon, potassium, sodium, percent nitrogen and saturation. It can be impressively used for rehabilitation of desertified rangeland and improvement of degraded rangeland in arid regions. In addition, Salsola arbusculiformis could be a good fodder resource for sheep and goat. Six month of vegetative growth in this species is grazing time.

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