Int. J. Forest, Soil and Erosion, 2013 3(3): 92-94

ISSN 2251-6387
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Research Paper

Effect of vegetation patches as micro-habitats on changing the soil properties (Case study: Saline rangelands surrounding Urmia Lake)

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Abstract: Plants change their environment's characteristics and specially soil properties to develop plant communities during their growth and adaptation. In this study, effects of halophyte patches surrounding Urmia Lake on chemical and physical properties of soil were investigated. In this regard, a vegetation type of *Salsola nitraria* and *Aeluropus littoralis*, which represents a broad area of salty pastures around Urmia Lake was chosen for field experiment, so 4 vegetation patches (ecological) were selected and the distance between them was considered as the bare soil without any cover (inter-patch space). Then along two transects with length of 150 meter which were established in parallel to the direct of slope, vegetation patches were measured and soil samples were taken from them and inter-patch spaces with four replications from two depths of soil profile. Soil samples of surface profile were taken from the soil surface up to 15 centimeter depth and the samples of second profile was taken from the depth of 15 to 30 centimeter. After drying the samples, their physical and chemical properties were measured and using independent T-test, the measured parameters were investigated for comparing the ecological patches and inter-patch spaces. The results showed that vegetation patches had significant effect on increasing soil total phosphorus and decreasing soil acidity, electrical conductivity, and soluble salts including sodium, potassium and calcium in soil samples of surface profile (0-15 cm) in patches and inter-patch areas, while there was not any significant difference in nitrogen and silt content of soil from patches and inter-patches. Moreover, comparing these properties in soil samples of second depth (15-30cm) showed that there weren't any significant differences between patches and inter-patches, and these results indicates the effect of vegetation patches and specially their roots on changing chemical properties of surface soil.

Key words: vegetation patches, chemical and physical properties of soil, saline rangelands, Urmia Lake.

Introduction

Arid and semiarid lands make up about 40 percent of Earth's land. In these areas, vegetation is generally in the form of patches which are composed of permanent shrubs. The certain thing is that patchy distribution of vegetation is a result of complex interaction of soil and plants and often the plants can improve the chemical and physical properties of soil so that pH is decreased, phosphorus, nitrogen, and percentages of sand are increased, and it also reduces the ratio of clay to bare soil (Bochet *et al.* 1999). In confirmation of this, Jafari *et al.* (1385) reported that among the environmental factors, soil is the most important factor in the formation and distribution of vegetation. Moreover, it is stated that the plants also influence the nutrient cycles and spatial soil characteristics.

Due to the harsh life conditions in the arid and semi-arid areas, small habitats that are formed by the patchy distribution of plants provide the necessary conditions for the establishment of plant communities with decreasing temperature, increasing the density of the food and preventing soil crust (Reza Shatery and Sepehri, 1389). Weinr *et al.* (1997) reported that the micro-habitats, formed by the herbal patches, as fertile islands are important factors in the development of vegetation and improvement of topsoil properties and also they believe that these micro-habitats are of extreme significance in salty desert ecosystems which have highly poor vegetation growth conditions and supplies.

In more than 100 countries, soil salinity is one of the main issues raised in the exploitation of the lands. In support of this idea, Qadir *et al.* (1998) stated that soil salinity as a long-standing problem due to reduced rainfall and improper management of water resources is increasing day by day. In addition, Na^{+} ،Ca^{2+} and K^{+} cations are known as the major soluble salts in salty soils which cause the ion toxicity and as a result reduce the ability to utilize the soil. Reduction in the amount of cations in the areas with halophytes of the *Suaeda* spp., *Salsola* spp. and *Haloxylon* spp. genus have also been reported by Yasin Ashraf *et al.* (2010).

Investigating the patchy distribution of plants and their effect on improving soil properties compared to bare soil around these herbal patches can be useful in predicting the efficiency of pasture and rangeland improvement projects of the pastures under plantation (pasture making in salt marsh) in developing soil properties. In this vein, the present study was conducted in saline pastures around Urmia Lake to examine the impact of halophyte vegetation patches as the micro-habitats on the soil nutrients and the physical and chemical properties of soil with the influence of halophytes' rooting.

Materials and Methods

To carry out the present study, first, in a vegetation type of *Salsola nitraria - Aeluropus littoralis* species representing a broad area of salty pastures around Urmia Lake, 4 herbal patches (ecological) including species with similar coverage; *Salsola nitraria*, *Sa. dendroides*, *Sa. Gemmascens*, *Sa. Lacrina*, *Sa. Soda*, *Aeluropus littoralis* and *Tamarix kotschyi* were selected and the intervals between them were considered as bare soil without any cover or inter-patch spaces.

The mentioned species are of the major elements of local habitats and especially *Salsola nitraria - Aeluropus littoralis* plant type which are distributed in south west saline pastures of Urmia Lake with the geographical position of 37 degrees and 25 minutes north and 45 degrees 16 minutes east. The average annual rainfall of the area is 299 mm and its climate based on Emberger classification method is semi-arid. Since the investigated areas supply the needed forage for large and small cattle (which are highly dense in surrounding villages) in most parts of the year, they play the major role in providing the necessary forage for the ranchers of the saline pastures around Urmia Lake. Animal type used in Tezkharab pastures is cow with a mixture of native and modified cattle and sheep, and goat breeds of Maku. Utilization method of the area is rural and from early May to late October every year, for 210 days the area is used by ranchers and farmers.

After selecting the investigated area, vegetation patches along two transects of 150 m parallel to the direction of the slope were measured and soil samples were taken from the patches and inter-patch spaces from 2 depths of 0-15 and 15-30 cm with 4 replication. After drying the samples, their physical and chemical properties were measured. Therefore, soil samples were passed through a 2-mm sieve. In the next step, pH and the electrical conductivity parameters of the soil were estimated with soil saturation extract and pH and EC meters, silt percent with hydrometric method, amount of Nitrogen with Kjeldahl method, Phosphorus using extraction with sodium-bicarbonate and Olsen method, and finally, Soluble sodium, potassium and calcium cations with replacement of ions by NH^{4+} or ammonium acetate (pH=7).

For statistical data analysis, $SPSS_{17}$ software and independent T-test were employed to compare the measured parameters in 2 areas having patches and the bare soil between the patches.

Results

The comparison of means for measured parameters in surface (0-15cm depth) indicated a significant difference in the amount of sodium cation ($P<0.01$), electrical conductivity and potassium content ($P<0.05$), and also the amount of acidity, calcium and phosphorus ($P<0.1$) in the soil of vegetation patches and the bare soil around them so that the amount of sodium cations in the soil of vegetation patches was 1.78 times less than the inter-patch space. Moreover, the presence of plants decreased the electrical conductivity and potassium cations of the soil within patches more than 2 times. The amount of calcium in patches was also 2 times less than the calcium in inter-patch space. However, in relation to soil nutrients, phosphorus of the tested samples was 2.3 times more than the bare soil between patches. About the soil acidity, it can be said that the presence of plants reduced its amount. Also, in relation to nitrogen and silt, despite the lack of significant differences, inside the ecological patches numerically more nitrogen and silt were found than in the soil of areas between vegetation patches (Table 1).

Table 1. Analysis of variance and mean (Mean ± SE) of soil properties in vegetation patches and inter-patch areas in upper surface (0-15cm depth) in saline pastures around Urmia Lake

Change Resources / Properties	Place	Mean	F	Sig
pH	Patch Inter-patch	8.73±0.070 8.51±0.088	0.334	0.094*
EC (millimhos)	Patch Inter-patch	4.91 ±1.07 10.32±1.92	3.033	0.049**
Nitrogen Percent	Patch Inter-patch	0.074 ±0.017 00.068 ±0.017	0.816	ns0.93
Phosphorus (ppm)	Patch Inter-patch	29.61 ±7.04 12.81 ±1.95	5.870	0.061*
Silt Percent	Patch Inter-patch	40.00 ±3.74 37.0 ±9.25	6.122	ns0.774
Na^+ (milliequivalents/l)	Patch Inter-patch	54.57 ±9.23 97.25 ±5.53	0.201	0.007***
K^+ (milliequivalents/l)	Patch Inter-patch	1.80 ±0.24 3.75 ±0.58	2.388	0.021**
Ca^{2+} (milliequivalents/l)	Patch Inter-patch	13.5 ±3.17 27.25 ±6.25	1.070	0.098*

*** (α= 0.01), ** (α=0.05), * (α=0.1), (ns=No significant difference)

Investigating the properties of soil samples taken from the lower horizon (15-30cm depth), which was to a lesser extent affected by the rooting of plants, significant differences were not observed between the studied parameters in the soil of vegetation patches and inter-patch areas, and numerical differences represent only the reduction in the amount of saline elements, electrical conductivity, silt, nitrogen nutrients and phosphorus in the areas having these patches. Also, soil acidity was found in the soil of ecological patches to be slightly more than the bare soil between patches (Table 2).

Discussion and Conclusion

Based on the results of the statistical analysis, in the surface horizon (first depth), which is more influenced by plant roots, chemical properties of the soil in the patches were different from those of the inter-patch spaces while the presence of a patch of plants has not produced a significant difference in the soil properties of the lower surface (15-30cm depth) compared to the soil between patches which can be due to the presence of plants root with more density in the first depth of soil profile. The absorption and secretion of different compounds through root can effectively change the properties of the soil in the rooting zone of plants (Kuzyakov *et al.* 2009). Also, Carcavaca *et al.* (2010) reported that reduction of acidity and increase of nitrogen and phosphorus of the soil can happen under the influence of vegetation patches resulting from the *Stipa tenacissima*, *Rosmarinus officinalis*, *Olea europaea*, *Pistacia lentiscus*, *Retama sphaerocarpa* and *Rhamnus lycioides* species. Regarding the reduction of soil acidity in vegetable patches, H^+ ion uptake by plant roots appears to be effective in reducing soil acidity (Qadir *et al.* 2005). Furthermore, the 2-fold increase of phosphorus in the areas with patches is due to the role of these micro-habitats in preserving soil nutrients in the local scale and regional rooting depth of the soil in which the physical, chemical and biological properties of the soil influenced by root and microbial activity varies and therefore is considerably different from bare soil. Such changes in soil properties affect the plant community structure and ecosystem functioning, particularly in steppes and deserts (Li *et al.* 2010). Decrease in the amount of inorganic salts containing Na^+, $Ca2^+$ and K^+ cations inside the vegetation patches and plants rooting depth is the indicator of the role and importance of plants' presence in reducing the soil salinity which in turn can be caused by the high potential of halophytes in the absorption of soluble salts from the soil. Reduction of the Na^+, $Ca2^+$ and K^+ cations in the soil for the presence of *Leptochloa fusca* has been reported by Akhter *et al.* (2003). Meanwhile, Ravindran *et al.* (2007) have also reported the reduction of mentioned cations under the influence of *Suaeda martimia*, *Clerodendron inerme*, *Sesuvium portulacastrum*, *Ipomoea pes-caprae*, *Excoecaria agalloch* and *Heliotropium carassavicum* species. Moreover, reduction of the electrical conductivity of the soil in the vegetable patches can also be caused by the presence of ion uptake by the plants roots. Shekhawat *et al.* (2006) reported the soil electrical conductivity decrease upto 85% for the presence of *Haloxylon recurvum* and *Suaeda nudiflora* species. Small-scale spatial variations of soil properties results in access to food and improvement of soil characteristics that can affect vegetation dynamics, litter production and decomposition, and nutrient cycling which is a key to the development and sustainability of ecosystems (He *et al.* 2009).

Table 2. Analysis of variance and mean (Mean ± SE) of soil properties in vegetation patches and inter-patch areas of deeper surface (15-30cm depth) in saline pastures around Urmia Lake)

Change Resources / Properties	Place	Mean	F	Sig
pH	Patch Inter-patch	8.58±0.104 8.43±0.047	1.210	0.225^{ns}
EC (millimhos)	Patch Inter-patch	5.40 ±1.31 9.85±2.52	6.816	0.185^{ns}
Nitrogen Percent	Patch Inter-patch	0.096 ±0.13 0.099 ±0.018	0.401	0.861^{ns}
Phosphorus (ppm)	Patch Inter-patch	25.09 ±9.07 26.14 ±10.14	0.009	0.941^{ns}
Silt Percent	Patch Inter-patch	36.5 ±7.55 37.0 ±5.97	0.168	0.960^{ns}
Na^+ (milliequivalents/l)	Patch Inter-patch	57.65 ±9.033 74.35 ±10.73	0.12	0.279^{ns}
K^+ (milliequivalents/l)	Patch Inter-patch	2.25 ±0.51 3.77 ±1.015	1.293	0.228^{ns}
Ca^{2+} (milliequivalents/l)	Patch Inter-patch	16.25 ±4.60 19.25 ±2.32	1.547	0.582^{ns}

(ns=No significant difference)

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