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Effect of some soil properties on distribution of *Ceratocarpus arenarius* and *Aristida funiculata* in Mardan, Kashan Rangelands

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Abstract

In order to sustainable use of rangelands, it is necessary to recognize water, soil, and vegetation cover and analyze their relationships. Physical and chemical properties of soil are effective in distribution of plant species in local area. To determine the effects of some soil properties on species distribution of *Ceratocarpus arenarius* and *Aristida funiculata* in Mardan summer region of Kashan, three types of vegetative plants were identified including *Artemisia aucheri- Ceratocarpus arenarius*, *Artemisia aucheri-Eryngium bungei* and *Artemisia aucheri - Aristida funiculata*. Then data of 20 plots were collected for each type in the desert. After drilling 27 soil profiles and providing samples of 0-30 and 30-60 cm from soil depth, pH, EC, $CaCO_3$, organic carbon, $CaSO_4$, and gravel parameters and distribution of soil grain were determined in the laboratory. One-way analysis of variance was made using SPSS software. Analysis of variance showed that clay and $CaCO_3$ in the soil first depth and $CaCO_3$ and Gravel% in the soil second depth have significant differences in three vegetation types. Then to determine parameters affecting on separating vegetation types, principal components analysis was performed on 17 variables (16 soil variables and slope percentage) using PC-ORD software. Results of PCA indicated that in the first axis slope%, clay in the second depth and $CaCO_3$ and sand in the first depth, explain 61% of the variations and for the second axis included sand in the second depth and electrical conductivity and organic matter in the first depth, explain 38% of the variations. The results of the research show that *Ceratocarpus arenarius* was more dispersion in areas where the lower and upper layers of soil had less clay and $CaCO_3$ and *Aristida funiculata* is seen in lower layers of soil having more clay and more $CaCo_3$ and less organic carbon and EC in upper soil layers.

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Introduction

In order to study of sustainable use of rangelands, it is necessary to recognize water, soil, and vegetation and analyze their relationships. Some soil factors (physical, chemical and biological), humidity and temperature are necessary for optimum plant growth. The plant growth directly correlates with the available amount of soil nutrient and energy (Moghadam, 2009). Some of environmental factors such as moisture and soil nutrients had significant effect on plant-community. Available moisture for plant growth depends on the annual precipitation, penetrating water into the soil and soil field capacity. In an area with certain climate, soil texture highly affects on plant's growth and succeeding revitalization is more effective than chemical fertility of soil. Nutrients generally have secondary effects on plant growth of ranges, since the primary limitation is low soil moisture (Mesdaghi, 2007). Desert areas generally had poor vegetation, in that area, soil factors and topography have active role in herb establishment. Therefore, determine of soil factors that are effective in vegetation distribution had important role for range management. Chemical and physical soil properties are effective on inherent fertility and productive potential of ranges and range management method (Mesdaghi, 2007). Jafari *et al.*, (2005) 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 $CaCo_3$ (Jafari *et al.*, 2005). Jafari *et al.*, (2008) in another study in rangelands of Nodoushan Yazd province, Iran showed high relationships between vegetation distribution and soil properties. The most important soil properties for separation of plant type were soil texture, $CaSO_4$, Potassium, $CaCO_3$, and electrical conductivity (Jafari *et al.*, 2008). Naseri*et al.*, (2009) studied the relationship between some physical and chemical properties of soil and plant communities, they found a positive correlation between vegetation and soil factors. Some factors as soil texture, electrical conductivity, had correlated with vegetation type and special species (Nasery *et al.*, 2009). Zarei *et al.*, (2010) in study of relationships between soil properties and vegetation distribution in salty mountain of Qom, found that electrical conductivity, magnesium, chlorine and sodium were the most important factors affecting in vegetation separation (Zarei *et al.*, 2010). Lentz (1984) in study of 28 soil morphological factors reported that horizon texture, gravel, horizon thickness and soil structure type were the main factors related to vegetation type and they could be useful tools for distinguishing of vegetation types (Lentz 1984). Monier *et al.*, (2001) found significant relationships between distribution of vegetation and soil factors. Using DCA analysis, they showed high correlation of $CaCO_3$, pH, soil saturation and organic matter, electric conductivity and $CaSO_4$ with species vegetation. Using CCA analysis they found high correlation of $CaCO_3$, soil saturation, pH, organic matter and surface sediments with vegetation (Monier *et al.*, 2001). Xian-Li *et al.*, (2008) studied the relationships between vegetation and soil and topography in the dry valley of China. They used canonical correlation analysis (CCA) and multiple linear stepwise regression analysis (MLR). Their results affirmed that plant diversity was mainly correlated with soil water content, and soil water content was mainly determined by soil texture and clay content (Xian-Li *et al.*, 2008).

Mardan region is a rangeland that no research was performed for vegetation and soil properties on this area and this is because of it is far from the province center, Esfahan. The aim of this research was examine the effect of soil properties on distribution of *Ceratocarpus arenarius* and *Aristida funiculata* that are palatable and dominate plant in Mardan, Kashan rangeland.

Materials and methods

The Mardan village is located in 42 km southeast part of Kashan city in Esfahan province. The study area includes ranges of Mardan village between 31°44'00″ and 31°48'30″ (North) and 55°53'00″ and 55°57'30″ (East) with an approximate extent of 2500 hectares.

Its altitude ranged from 2310 to 2980m above sea level. Average annual rainfall is over 97 mm, mean annual temperature is 14.26 °C, warmest month is July and the coldest month is January. The minimum and maximum temperatures were recorded -24°C and 45.7°C, respectively.

Ceratocarpus arenarius is belong to Chenopodiaceae family. Geographic dispersion of this species in the mountainous area of Esfahan provinces is Bafq, Sheytoor plain, Neer, Nodoushan and Dehbala (Mozafarian, 2000). *Ceratocarpus arenarius* is native plant of desert ranges, which has special importance in arid and semi arid area due to having shrub form, resistant to aridity, high protein value and its simple propagation. These characteristics have led to utilization in restoration and improvement of ranges (Filekesh *et al.*, 2006). *Aristida funiculata* is belongs to the Gramineae family. Geographic dispersion of this species is mountainous areas of Shirkooh, Ardakan, Bafq and Nodoushan. *Aristida funiculata* has high preference value in dry year in Esfahan province in terms of palatability and it is feeded by domestic animals early summer (Baghestani *et al.*, 2005).

In this research, primary vegetation type study was done using aerial photos and satellite pictures according to color variances and natural complications then transferred to topography maps and indentified as 3 types include 1) *Artemisia aucheri* - *Ceratocarpus arenarius* 2) *Artemisia aucheri* - *Eryngium bungei* and 3) *Artemisia aucheri* - *Aristida funiculata*. In order to study of density and cover of species in vegetation types, the random sampling was used and the plot size also obtained 1×2 square meter. 27 soil profiles (9 profiles in each type, possibly near the plot) were randomly drilled according to total extent of the studied area and separated vegetation types. Then according to the depth of root development of Aristida funiculata and Ceratocarpus arenarius, soil sample supplied from the two primary depth profiles (0-30 and 30-60 cm) with standard sum and reagent layer, and it was transported to the laboratory to determine the parameters required. Soil samples were passed through the sieve (two mm) and it was determined percentage of gravel dimension larger than 2 mm for each one. Then physical experiments for determining relative particles (percentage of clay, silt and sand) were performed using the hydrometer Baykas on particles smaller than 2 mm. In study of chemical parameters, percentage of organic matter were determined with Walki Bluk method (Nelson and Sommer 1982), $CaCo_3$ using volumetric method (Goh, *et al.*, 1980), $CaSo_4$ using Aseton method (Richards, 1954), pH with pH meter and electrical conductivity (EC) were determined using an electrical conductivity meter (ds/m).

In this research, one way variance analysis is used to compare the data sets of soil properties in vegetation types and also grouping of soil properties via Duncan's new multiple range test by SPSS16 software. Then to determine determine the most important parameters affecting on plant distribution of *Aristida funiculata* and *Ceratocarpus arenarius* were used of Principal components analysis by PC-ORD software. Principal components analysis, which is a line method which coordinates of sample unit, is determined by Linear combination from weighted Frequency of species in special new axis. If data have no linear relationship, this method cannot show relationship between sample units and needs not much precision to apply it (Moghddam, 2001).

Result and discussion

Comparing vegetation types according to soil properties

Results of oneway analysis of variance between three vegetation types were made separately for above and lower soil layer. Results from analysis of variance showed significant differences between plant community in the soil first depth for clay $P<0.05$) and CaCO3% ($P<0.01$) (Table 1). For the second layer, there were significant differences between vegetation types for CaCO3% ($P<0.01$) Gravel% ($P<0.05$) (Table 2). Soil properties category in above and lower depth are described in Table 3. For *Ceratocarpus* higher values were obtained for silt, sand, EC and gravel%. Whereas, for Aristida funiculata, the higher values were obtained for Clay%, CaCo3 and OC (Table 3).

Table 1. Results of one way variance analysis of soil properties in primary depth.

Type	Df	Clay (%)	Silt (%)	Sand (%)	pH	EC (ds/m)	$CaCO_3$ (%)	OC (%)	Gravel (%)
Between Groups	2	58.06*	60.62	5.354	0.001	0.044	27.76**	0.047	160.58
Error	24	15.15	38.02	38.22	0.022	0.024	5.916	0.043	95.18

*, **= significant at 5 % and 1%, respectively.

Table 2. Results of one way variance analysis of soil properties in secondary depth.

Type	Df	Clay (%)	Silt (%)	Sand (%)	pH	EC (ds/m)	$CaCO_3$ (%)	OC (%)	Gravel (%)
Between Groups	2	10.82	26.48	7.52	0.079	0.011	89.5**	0.013	227.7*
Error	24	29.41	38.28	27.07	0.034	0.015	14.01	0.010	83.96

*, **= significant at 5 % and 1%, respectively.

Table 3. Soil properties category in primary and secondary depth.

Type	Depth (cm)	Clay (%)	Silt (%)	Sand (%)	pH	EC (ds/m)	$CaCO_3$ (%)	OC (%)	Gravel (%)	$CaSo_4$ (%)
Artemisia-	0-30	11.37	35.04	54.91	7.81	0.67	12.40	0.36	33.77	0
Ceratocarpus	30-60	15.44	32.15	52.40	7.73	0.46	12.06	0.33	37.15	0
Artemisia-	0-30	12.98	32.57	53.43	7.83	0.53	13.47	0.26	31.40	0
Eryngium	30-60	16.30	32.47	51.22	7.91	0.39	16.87	0.25	35.70	0
Artemisia-	0-30	16.35	29.85	53.78	7.81	0.58	15.83	0.40	25.57	0
Aristida	30-60	17.62	29.35	35.02	7.88	0.42	18.00	0.30	27.80	0

Determining the affective parameters on vegetation types

In order to determine the most important effective parameters on separating three vegetation types in the region, principal components analysis (PCA) was performed on 17 variables (16 soil variables and slope%). Results showed that the first axis justifies 61% of the variation and second axis explains 38% of the variations (Table 4). The correlation between variable with axes showed that for the first axis, slope%, clay in the lower depth and $CaCO_3$ and sand in the upper depth. For the second axis, sand in the lower depth and EC and organic matter in upper depth were important factors for separation vegetation types (Table 4). Distribution of three vegetative types of Mardan are shown in Fig. 1. According to this diagram, the position of three vegetation types is different. Vegetation type of *Artemisia aucheri - Eryngium bungei* is located in first quarter (upper). According to the first and second axis properties, it could be found that this type has positively directed with Slope%, clay, pH and $CaCO_3$ and negatively directed with EC, Silt, Sand, OC and gravel%. In the third quarter, *Artemisia aucheri - Ceratocarpus arenarius* vegetation type is located. according to Fig 1. This type has inverse relationships with soil factors slope%, clay, pH and $CaCO_3$. Therefore, this type has been located at the lowest slope. In the fourth quarter, *Artemisia aucheri-Aristida funiculata* type is located according to Fig. 1.

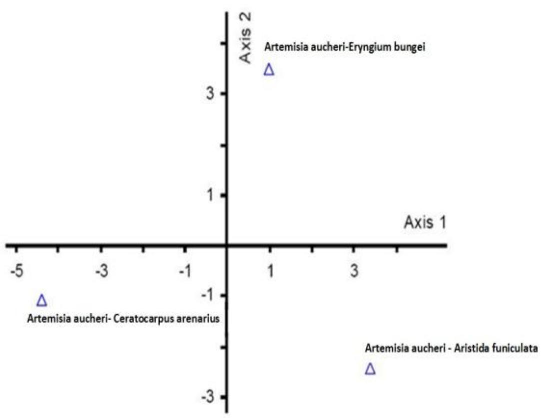

Fig. 1. Biplot diagram of first and second component from PCA analysis on soil properties and vegetation types.

This type has direct and positive relationships with the first axis factors including, slope%, clay $CaCO_3$ and negatively correlated with silt, sand, gravel%. This type of vegetation was located at the highest slope% but had positively direct relationship with EC and OC in the first depth (Table 4).

Table 4. Results of principal component analysis on soil properties and vegetation types.

Variable	PC1	PC2
Slope	**0.31**	0.03
Clay-1	**0.28**	- 0.16
Clay-2	**0.29**	- 0.13
pH-1	0.14	**0.35**
pH-2	0.28	0.17
$CaCO_3$-1	0.28	- 0.16
$CaCO_3$-2	0.31	0.05
EC-1	- 0.23	**- 0.25**
EC-2	- 0.22	**- 0.28**
Silt-1	**- 0.30**	0.10
Silt-2	- 0.21	**0.29**
Sand-1	**- 0.26**	- 0.20
Sand-2	0.04	**- 0.39**
OC-1	0.02	**- 0.39**
OC-2	- 0.17	**- 0.33**
Gravel-1	**- 0.27**	0.17
Gravel-2	**- 0.25**	0.22
Eigen value	10.52	6.47
% of Variance	61.93	38.07
Cum. % of Variance	61.93	100.0

Conclusion

Soil texture was very effective on humidity rate control and available food for plants. Soil with suitable depth and light texture; dispose the available water to plants more simply and properly. Soil texture was effective on plants vegetation type distribution. Since difference of humidity rate leads to variation in forming and aeration and salinity rate of soil. Some researchers as Jafari (2008), Jafari (2005), Zarei (2010), Lentz (1984), Naseri (2009) and xian-Li (2008) proved that the soil texture (clay, silt and sand), is one of the most important factors effective on plant type distribution. Adequate amount of CaCo3 in the first depth had considerable role in the creation of good structure. Nevertheless, if $CaCO_3$ increases too high level of soil, it leads to hardpan creation, increases pH, and it results in bad conditions for absorbing some of the elements and makes problems for plants. Some researchers such as Monier (2001), Jafari (2005) and Jafari (2008) concluded that $CaCO_3$ (calcium carbonate) is one of the important factors in the separation of plant types and it can affect the distribution of some plant species. Regarding the light soil texture in the total region, increasing rate of clay in soil can create balanced and suitable texture for permeability and water and food maintenance in soil. The results of this study indicate that the presence of *Ceratocarpus arenarius* had inverse relationship with slope%, clay in second depth and $CaCO_3$ in the first depth and positive relationship with EC, silt, sand, OC and gravel%. Therefore, *Ceratocarpus arenarius* requires the less clay in lower layers of soil and less $CaCO_3$ in upper layers of soil. Presence of *Aristida funiculata* in type 3 was associated with slope%, clay in second depth, $CaCo_3$ in first depth, EC and OC in the first depth. Therefore, *Aristida funiculata* needs more clay in lower layer of soil and more $CaCO_3$; and less organic carbon and EC in upper soil layers. Totally, among all of the investigated environmental properties, clay and $CaCO_3$ had a more important role in separation of vegetation types, presenting species of *Ceratocarpus arenarius* and *Aristida funiculata*. Consequently, according to vegetative properties, ecological needs and tolerant rate of each species had related to some soil properties, and these relationships are different for each species. Hence, the results obtained of each region can be extended only to the areas with similar conditions.

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