Plant species effects on soil properties in Nir rangelands of Yazd Province (Iran)

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Abstract--- In this study we investigated the impact of various plant index species such as *Artemisia aucheri*, *Artemisia sieberi*, *Astragalus albispinus* and *Stipa barbata* on soil properties in Nir rangelands of Yazd Province (Iran). Sampling of soil was performed with randomized-systematic method. In each key area, 20 soil samples were collected under the plant species crown (canopy) and in the space between pant crowns (interspace) at two depths, 0–30 and 30–60 cm. The measured soil variables included texture, lime, acidity (pH), electrical conductivity and values of N, P, K, C. To Comparing of the measured soil characteristics beneath plant species and adjacent control area, an independent t test (t-test) was used. The result of comparing soil characteristic under the plant species crown (canopy) and in the space between plant crowns (interspace) showed that soil had the highest significant differences between k and pH under the *Ar. sieberi* canopy and interspace. Similarly significant differences were observed for N and C in 0-30 cm under the *Ar. aucheri* crown and interspace, presence of *As. albispinus* alter amount of N and C in both layer and it had high significant differences in two area and soils had high significant differences with C and lime in 0-30 and 30-80 respectively between under the S. *barbata* canopy and interspace.

Keywords---Poshtkouh rangelands of Yazd Province, Soil characteristics, Plant index species.

I. Introduction

THE potential effects of plant species on soil properties have been a focus of study for a long time, and the associated plant–soil interactions provide important feedbacks that regulate ecosystem processes [4, 17, 20, 26]. Plant and soil are of the main components of a rangeland ecosystem. According to the high importance of soils and plants in human’s life, and also in order to have an appropriate management of a natural system, like rangeland ecosystem, understanding the relationship between plant and soil is of high importance. Plants are important components of terrestrial ecosystems because they play a central role in organic matter decomposition and nutrient cycling, there by affecting soil nutrient content and, consequently, primary productivity.

And soil is a complex and dynamic medium with a variable range of many physical (texture, density, water content), chemical (pH, nutrient status, solution chemistry) and other (cation exchange, organic matter content) properties [21]. Changes in soil physical properties associated with increased organic materials include temperature buffering, reduced evaporation, increased infiltration, increased retention, increased drainage, reduced splashing, decreased density, and increased porosity.

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This meta-analysis did provide substantial evidence that organic materials are associated with buffering of soil temperature, improving soil moisture status, decreasing density, and increasing porosity [21].

Payne [19] studied relationship between cover and yield of 48 plant species observed in 160 quadrats, in various vegetation communities of Beaverhead National Forest located in south western of Montana. He reported that the relationship between canopy cover and yield of 12 species had not been significant, for 36 species correlation coefficient was significant and for 16 species correlation coefficient was higher than 0.9.

Payne [19] suggested that similar investigation is required in each region to test relationship between cover and yield. Andariese and Covington (1986) believed that effects of over story on under story vegetation cover and local condition should be taken into account for increasing precision of this method. Many scientists including [10, 13, 19] emphasis on this point.

Various substances released by roots ,according to mode of release is (1) water-soluble exudates (sugars, amino acids, organic acids, hormones, and vitamins), which leak from the root without involvement of metabolic energy; (2) secretions (polymeric carbohydrates and enzymes), which depend on metabolic processes for their release; (3) lysates, released when cells autolyse; and (4) gases From a soil perspective, the release of organic materials from roots, even though it represents a small proportion of the total rhizo deposition, is extremely important because these compounds influence nutrient availability through the regulation of the microbial biomass community and activity [11].

The ability of roots to explore the belowground environment in urban settings influences tree plant health, stability, and longevity. However, few studies have addressed rooting response of urban trees plant to specific characteristics of the belowground environment (for a general view of root architecture in urban settings, see Day et al. 2010b).

Baghestani Maybodi et al [3] investigated relationship between canopy cover and yield of some important range species in Yazd’s rangeland were investigated.

The characteristics soil and effects of plant species have received increasing attention from ecologists, conservationists, and land managers.

Plant species also able to alter the habitat, they are likely to modify the structure and soil composition in habitat [6].

In the very ecosystems it has been observed that changes of plant cover during ecological succession may influence the soil microbial community.

Timsina et al [24] in rangelands communities in Nepal founded significant differences between invaded, transitional and non-invaded plots in species composition and soil properties.

Plants can have beneficial effects on the soil properties mainly through their root exudates. Thus, our examination of our study is that how four plant species influence soil mineralization processes and compare impact of plant index species such as *Artemisia aucheri*, *Artemisia sieberi*, *Astragalus spp.* and *Stipa barbata* on soil properties.

Relationships between soil properties and the dominance of certain plant species in a natural environment may aid in tailoring appropriate species mixes for specific soil types in a managed rangeland environment [22, 28]. Thus, our examination of how plant species influence soil mineralization processes and how soil physical and chemical properties relate to the influence can give great insights in to understanding nutrient cycling in a rangeland ecosystem. In this study, we investigated the effects of individual plant species in decomposing soil organic matter. Then, we will discuss the ecological consequences of the impacts of four species on soil mineralization process.

II. Material And Methods

A. Study Area

This study was conducted in Nir rangelands with an area of 170000 ha. Nir rangelands are located in the southern slopes of the Shirkouh mountains of the Yazd province in the central Iran (31°33′ 11″ N, 53°40′06″ E to 31°04′27″ N, 54°15′19″ E).The maximum elevation of the region is 3990 m a.s.l. and the minimum elevation is 1400 m a.s.l. Average annual precipitation of the study area ranges from 270 mm in Shirkouh mountain to 45 mm in margin of Kavir-e-Abarkouh. Average annual temperature ranges from 17.1 to 10.8°C. Meteorological data were calculated for a ten-year period.

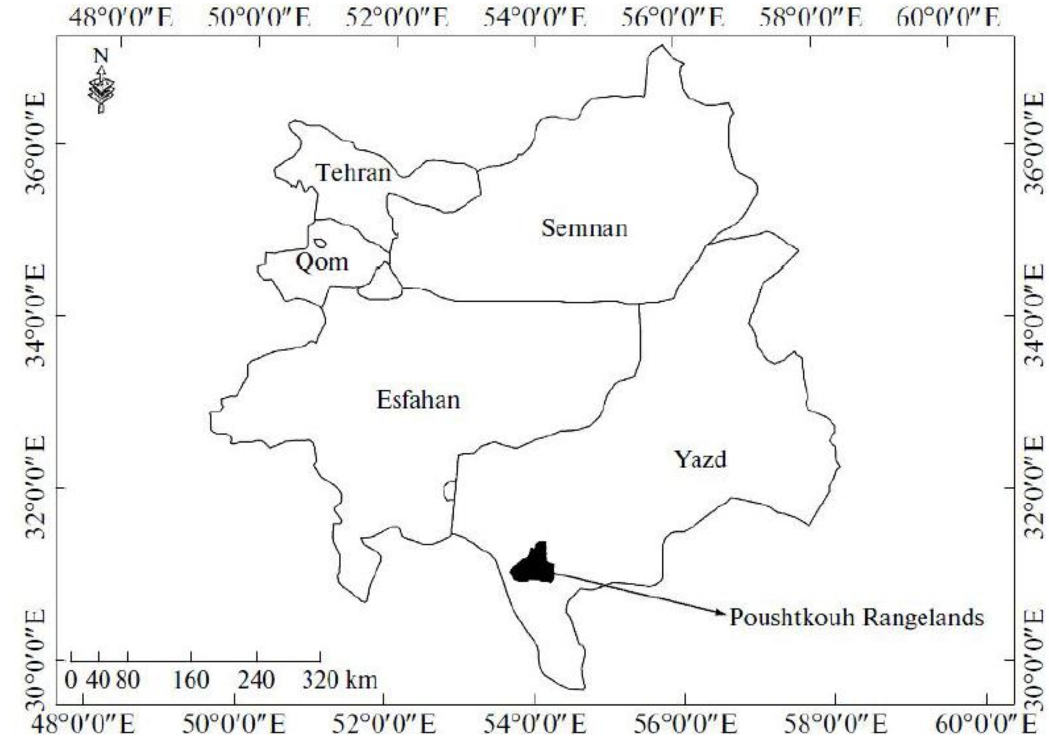

Fig 1. Location of study area

B. Data collection

Based on four plant index species and dominance plant species (*As. albispinus*, *Ar. aucheri*, *Ar. sieberi* and *S. barbata*), soil sample under plant species canopy and in the space between pant crowns (interspace) was determined for sampling. In each key area, 20 Soil samples were taken from 0-30 and 30-60 cm layers.

Measured soil factors included texture (determined by Bouyoucos hydromerter), organic carbon (determined using Walkelyand Black rapid titration, Black, 1979), pH in saturation extract (determined bypH meter), electrical conductivity (ECe) (determined by conductivity meter), lime (determined using 1 n HCl, [14]), N (Kjeldhal method), P (spectrophotometery) and K (flame photometer method). Finally, independent t test (t-test) was used to analyze the obtained data, using SPSS 15 (Institute of Soil Science, CAS, 1978).

III. Results

Table 1 shows the result of t-test for chemical properties in different parts of *As. albispinus* which shows a significant difference ($P<0.01$) between under plant species canopy and in the space between plant crowns (interspace) and it shows that amount of N and C in both layer are significantly different ($P<0.05$) in the two area.

Table 1 also shows the result of t-test for physical and chemical properties in different parts of *Artemisia aucheri* which shows a significant difference ($P<0.01$) between under plant species canopy and in interspace and result showed the positive relationship and significant differences with N and C in 0-30 cm in the two area.

Based on t-test analyses significant differences were detected for some soil characteristics, such as k and pH between soil samples collected under the *Ar. sieberi* canopy at depths 0-20 cm and samples collected from the space between plant crowns (interspace).

Similarly significant differences were observed for C and lime value at 0-20 cm and 30-80 cm depths respectively between *S. barbata* canopy and its interspace.

TABLE I
COMPARISON OF SOIL CHARACTERISTICS (MEANS ± S.E.) BETWEEN THE CANOPIED AREA (CANOPY) AND INTERSPACES BETWEEN CANOPIES (INTERSPACES) OF *AS. ALBISPINUS*, *AR. AUCHERI*, *AR. SIEBERI* AND *S. BARBATA*

Soil properties	Treatment	Mean				df	t statistic			
		Astragalus albispinus	*Artemisia aucheri*	*Artemisia sieberi*	*Stipa barbata*		*As.albispinus*	*Ar. aucheri*	*Ar. sieberi*	*S barbata*
Clay1 (%)	Canopy	1.84 ± 16.75	1600 ± 1.74	16.07 ± 0.88	18.70 ± 1.90	10	0.60ns	0.25ns	2.44*	0.52
	Interspace	15.4 ± 0.6	15.4 ± 0.6	20.97 ± 1.8	17.70 ± 1.03					
Clay2 (%)	Canopy	19.25 ± 3.27	21.24 ± 1.15	16.70 ± 0.1	15.60 ± 1.00	10	1.20ns	1.31ns	1.57ns	1.76
	Interspace	24.8 ± 3.06	24.80 ± 3.05	15.03 ± 0.35	19.10 ± 1.26					
Silt1 (%)	Canopy	11.4 ± 4.12	11.00 ± 2.07	16.00 ± 1.22	16.60 ± 0.60	10	0.53ns	0.77ns	0.66ns	0.37ns
	Interspace	8.8 ± 0.4	8.80 ± 0.40	17.53 ± 1.88	15.10 ± 2.67					
Silt2%	Canopy	12.4 ± 4.14	14.48 ± 1.32	6.47 ± 1.03	5.00 ± 3.00	10	0.09ns	0.87ns	3.26**	2.494ns
	Interspace	11.87 ± 3.33	11.87 ± 3.33	2.60 ± 0.58	12.00 ± 1.41					
Sand1%	Canopy	71.85 ± 5.75	72 ± 3.74	67.93 ± 1.92	64.70 ± 1.30	10	0.58ns	0.76ns	1.63ns	0.49ns
	Interspace	75.80 ± 0.2	75.80 ± 0.20	61.50 ± 3.43	67.20 ± 3.34					
Sand2%	Canopy	68.35 ± 6.81	64.28 ± 2.01	76.83 ± 1.94	79.40 ± 2.00	10	0.52ns	0.18ns	2.58*	2.96ns
	Interspace	63.33 ± 6.36	63.33 ± 6.36	82.37 ± 0.91	68.90 ± 2.22					
K1(ppm)	Canopy	210 ± 17.32	140 ± 17.89	200 ± 5.16	120 ± 0.00	10	4.86**	1.37ns	2.95*	2.12ns
	Interspace	106 ± 6.67	107 ± 6.67	150 ± 16.12	140 ± 0.00					
K2 (ppm)	Canopy	155 ± 33.04	168 ± 16.25	107 ± 4.22	90 ± 10.00	10	0.28ns	0.05ns	3.13*	2.36ns
	Interspace	167 ± 17.64	167 ± 17.64	83.33 ± 6.15	145 ± 15.00					
P1 (ppm)	Canopy	20.50 ± 2.24	16.56 ± 0.43	16.67 ± 1.27	17.80 ± 5.40	10	1.20ns	0.20ns	1.06ns	0.33ns
	Interspace	16.80 ± 1.4	16.80 ± 1.4	16.00 ± 0.92	20.60 ± 5.26					
P2 (ppm)	Canopy	19.20 ± 2.9	17.68 ± 0.54	11.70 ± 1.21	9.20 ± 0.00	10	0.42ns	0.054ns	1.79ns	3.12*
	Interspace	17.73 ± 0.93	17.73 ± 0.93	9.47 ± 0.3	13.30 ± 0.85					
N1 (%)	Canopy	0.055 ± 0.01	0.042 ± 0.006	0.025 ± 0.006	0.010 ± 0.00	10	2.31*	2.76*	0.44ns	1.15
	Interspace	0.017 ± 0.01	0.0167 ± 0.01	0.030 ± 0.01	0.015 ± 0.85					
N2 (%)	Canopy	0.0325 ± 0.01	0.028 ± 0.01	0.010 ± 0.00	0.010 ± 0.00	10	2.41*	1.80ns	1.00ns	0.00
	Interspace	0.0133 ± 0.00	0.0133 ± 0.00	0.008 ± 0.002	0.015 ± 0.00					
OM1 (%)	Canopy	0.55 ± 0.12	0.41 ± 0.06	0.258 ± 0.05	0.11 ± 0.01	10	2.42*	2.55*	0.27ns	3.22*
	Interspace	0.17 ± 0.08	0.17 ± 0.08	0.288 ± 0.09	0.18 ± 0.02					
OM2 (%)	Canopy	0.36 ± 0.06	0.276 ± 0.05	0.097 ± 0.017	0.075 ± 0.02	10	2.83*	1.90ns	1.04ns	3.38ns
	Interspace	0.12 ± 0.05	0.117 ± 0.05	0.068 ± 0.021	0.142 ± 0.01					
Lim1 (%)	Canopy	0.50 ± 0.10	48 ± 0.80	6.47 ± 0.50	7.05 ± 0.45	10	1.24ns	1.43ns	1.09ns	0.18ns
	Interspace	3.03 ± 2.43	18 ± 2.44	7.12 ± 0.32	7.15 ± 0.33					
Lim2 (%)	Canopy	0.50 ± 0.1	48 ± 0.80	6.67 ± 0.55	5.40 ± 0.40	10	0.96ns	1.12ns	0.74ns	2.78*
	Interspace	1.8 ± 1.6	18 ± 1.6	5.90 ± 0.88	9.02 ± 0.85					
pH1	Canopy	7.42 ± 0.02	7.44 ± 0.04	7.82 ± 0.03	7.90 ± 0.00	10	1.81ns	1.74ns	2.71*	0.67ns
	Interspace	7.63 ± 0.13	7.63 ± ± 0.13	7.90 ± 0.00	7.87 ± 0.025					
pH2	Canopy	7.47 ± 0.07	7.44 ± 0.074	8.02 ± 0.02	7.90 ± 0.00	10	1.24	1.48ns	0.53ns	0.67ns
	Interspace	7.60 ± 0.06	7.60 ± 0.6	7.98 ± 0.06	7.92 ± 0.025					
EC1 (ds/m)	Canopy	0.20 ± 0.041	0.1 ± 0.00	0.200 ± 0.03	0.15 ± 0.05	10	0.60ns	1.74ns	0.41ns	0.00ns
	Interspace	0.17 ± 0.03	0.167 ± 0.03	0.183 ± 0.02	0.15 ± 0.03					
EC2 (ds/m)	Canopy	0.125 ± 0.02	0.12 ± 0.02	0.100 ± 0.00	0.20 ± 0.00	10	0.84ns	0.75ns	0.00ns	0.00ns
	Interspace	0.100 ± 0.00	0.1 ± 0.00	0.10 ± 0.00	0.20 ± 0.00					

IV. Conclusions

Different plant species had significant impacts on soil characteristics, soil physicochemical properties, and substrate qualities were significantly different among the plant species.

Because organic matter accumulates on the rangeland floor and our soil samples were from the highly organic top 5-cm soils, we suggest that theses pecies-specific differences are primarily due to the difference in above-ground litter quality and quantity. Actually, the quality of litter that was shed under the plant index species canopies were clearly different.

This survey clearly shows that species plants can greatly alter ecosystem processes. However, the soils may result in increases, decreases, or no difference between the plant canopy and the interspace. Furthermore, the alteration of one process does not necessarily result in changes in related processes. Similarly, differences in one component of a cycle do not necessarily imply differences in linked components of the same cycle [9].

According to the results significant differences were detected for soil characteristics, except for Electrical Conductivity, between soil samples collected from under *Ar. sieberi*, *Ar. aucheri*, *As.albispinus* and *S. barbata canopy* and samples collected in the space between pant crowns (interspace). That as significant differences between Acidity, Clay in 0-30 depth and Silt, Sand in 30-80 depth and Potassium in both layers in *Artemisia sieberi* canopy and interspace. Similarly significant differences were observed for Nitrogen and Carbon in 0-30 cm in undder *Artemisia aucheri* canopy and interspace, presence of *As.albispinus* alter amount of Nitrogen and Carbon in both layer and Potassium in 0-30 cm depth, it had high significant differences in two area and soils had high significant differences with C and Lime, Potassium in 0-30 and 30-80 respectively between *Stipa barbat* canopy and interspace. This relationship has also been observed in previous studies and is generally explained by inhibition of acid phosphatase activity by inorganic phosphor [18, 23].

The result showed that *As.albispinus* and *A.aucheri* increased the amount of Carbon under plants. In fact vegetation absorbs the atmosphere's carbon dioxide in cycle of carbon photosynthesis process and reserves them into organic carbon includes x-ose (e.g. fructose) so that is called carbon sequestration. Although the rate of carbon sequestration of rangelands is slight, its space can rectify it [1, 25]. In conclusion, soil mineralization activities were significantly different among plant species. A higher acid phosphatase activity under *As.albispinus* canopy than those under the other plant species can compensate for a lower concentration of Phosphor in various fractions under *As.albispinus* canopy. This pattern suggests that a compensation for Phosphor availability in soils where the concentration of available Phosphor is lower.

Plant root systems form part of a complex matrix that can stabilize soil and reduce erosion, both important contributions to environmental sustainability. Soil inhabited by plants dries more quickly due to transpiration; as a result, the soil has greater shear and tensile strength and the root/soil tangential resistance to slipping will be increased [7].

Drought can increase soil strength in many soil types as soil strength increases with decreasing soil water content. Indeed, drying soils can become strong enough to affect root growth at soil water matric potentials as high as −0.1 MPa [6].

Finally, we suggest that soil mineralization activity has important impact nutrient cycling in the rangeland. Previous studies suggested that poorly decomposable litter often decrease the fertility of soils [12, 27]. For example, in nutrient-poor ecosystems, plants grow slowly, use nutrient efficiency and produce poor-quality litter that decomposes slowly. The slow decomposition results in a low mineralization rate, and in turn a slow supply rate of inorganic nutrient for plants. However, unlike previous studies, our study reported an opposite pattern in Phosphor mineralization process, which was thought to be a limiting factor of plant growth in this ecosystem [15, 16]. Soil under the plant crown of index species contained a relatively low concentration of Phosphor invarious fractions. This localized mineralization activity and the soil properties could subsequently influence soil nutrient availability in this rangeland.

In conclusion, cycling of mineral elements in degraded rangelands by decomposition of plant species would help to rehabilitate rangelands.

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