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Comparison of chemical characteristics of shoot, root and litter in three range species of *Salsola rigida, Artemisia sieberi* and *Stipa barbata*

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ABSTRACT

Some chemical characteristics of root, shoot and litter of index species such as *Salsola rigida, Artemisia sieberi* and *Stipa barbata* commonly used in rangeland development projects were evaluated and compared. Chemical properties of soil under and between the above mentioned species were also studied. For this purpose, vegetation types of *Stipa barbata* and *Artemisia sieberi* - *Salsola rigida* were selected in Zarand-e-Saveh rangelands. Totally, 30 individuals of each species within each type were randomly selected for shoot, root and litter sampling and chemical analyses. Also, values of N, P, K, C and C/N ratio were measured in different parts of the species. Results showed that the highest and lowest C/N ratios were related to *Stipa barbata* root and *Artemisia sieberi* shoots, respectively. N and P values of *Stipa barbata* litter were the lowest while *Artemisia sieberi* and *Salsola rigida* shoots had the highest values of P and N, respectively. Litter of *Salsola rigida* and shoot of *Artemisia sieberi* had the lowest and highest K, respectively. C/N ratio of *A. sieberi* soil was lower than rest of the species.

Keywords: *Plant tissue, vegetation cover, rangeland, Iran, soil characteristics.*

INTRODUCTION

Planting of different species, especially introduced ones, may lead to different positive or negative changes in soil and vegetation characteristics of a region. Understanding the type and severity of effects resulting from different species, helps us to select suitable plants when performing a vegetation development project. Plant life forms or species providing different quantity and quality of litter may play different roles in nutrient cycling and ecosystem functioning (Hoorens *et al*., 2002; Bertiller *et al*., 2005). The nutrients and litters returning from shoots or root of plants to the soil, are of high importance because of their effects on soil physical-chemical properties and on associated plants. Reyisi *et al* (2003) reported that massive litters of slow – decomposable plants like *Hordeum* resulted in absorption of N by micro organisms which in turn leads to immobility of N. They suggested that under mentioned conditions, alfalfa planting, according to its high quality litter, helps to reform the soil.

The role of plant tissue chemistry and its decomposition on nutrient cycling in grasslands has been reviewed and conceptualized by Wedin (1995, 1999). Jafari and Rahimzadeh (2004) investigated the relationship between litter and soil properties in habitats of *Artemisia aucheri*, *Artemisia sieberi* and *Acantholimon tragacanthinum.* They found that K and P amounts in species litters and habitat soil follow a similar trend. Franck *et al* (1997) stated that C/N ratio was smaller in *Lolium prenne* litter compared to *Avena sativa*. They supposed that due to lower C/N ratio, *Lolium prenne* litter quality was higher. Litter quality of *Leucaena* and *Sesbania* was studied by Lupwayi and Haque (1998). They reported that mentioned plants are different in view point of their N, K, and Mg amounts while little difference was observed in P and Ca amount of the two plants. They explained that decomposition speed of *Leucaena* was higher than *Sesbania*. Throop *et al*. (2004) reported that decrease in C/N ratio leads to increase in mineralization speed and humus formation. Rates of leaf litter decomposition are regulated by a hierarchy of interacting physical, chemical and biotic factors (Couteaux *et al*., 1995; Heal *et al*., 1997). Madritch and Mark (2004) examined effects of species diversity on N and C variation. They concluded that N and C cycle is affected by phenotypic variation.

Generally, in vegetation development and reclamation projects, only species adaptability is considered as a key criterion for plant selection. Adaptability to new conditions is an important criterion but some other characteristics such as forage quantity, forage quality, production sustainability, re-vegetation and litter quality are other criteria that should be noted when one or more species are selected for planting in a given area. The current research focuses on litter quality and nutrients status in belowground and aerial parts of three well-known species *A. sieberi*, *S. rigida* and *St. barba*, which are widely used in Iran's rangelands reclamation projects.

MATERIALS AND METHODS

The study area is located in steppic rangland of Zarand-e-Saveh in Markazi Province (longitude of 46° 54' 35″ to 46° 72' and latitude of 39° 42' 55″ to 39° 43' 18″). Average slope and elevation of the area are 8% and 1518 m above sea level, respectively. The majority of the study region is located in plains. Mean annual precipitation of the study area is 240 mm. Based on Emberger method, the climate is cold semi arid.

Two vegetation types including *S. barbata* and *A. sieberi* – *S. rigida* were selected. Within each type one key area was determined for sampling. In each key area, 30 individuals of each species were randomly selected for aerial (shoot) and underground parts (root) in addition to litter sampling. Samples were taken at the end of fall season. Aerial parts were put in oven at 70°C for 24 hours in the Soil and Plant Laboratory of Faculty of Natural Resources, University of Tehran. Litter and underground samples of species were washed following the floating method and similar to aerial parts, they were put in the oven under the same condition (Hartemink *et al*, 2001). When samples were completely dried, they were powdered. Using obtained powders, the following properties were determined: C (burning in furnace), N (Kjeldhal method), P (spectrophotometery), K (flame photometer method).

Six profiles were dug in each vegetation type and soil samples were taken from 0-20 and 20-50 cm. To find out the effects of plant species on soil properties, some soil samples were collected from adjacent control areas of each vegetation type. The properties of N, P, K, C and C/N ratio were determined for soil samples. Finally, ANOVA test was used to analyze the obtained data, using SPSS 15.

RESULTS

Plant chemical properties

Table 1 shows the result of ANOVA for chemical properties in different parts of the three species which shows a significant difference ($P<0.01$) between *St.barbata*, *A.sieberi* and *S.rigida* based on N, K, and C in their litter samples. Also N of belowground parts, P of aerial parts and K of litter are significantly different ($P<0.05$) in the three species. The results of Duncan's test (Fig. 1) reveal that N of aerial parts in *S.rigida* and *A.sieberi* (%1.1 and %1.2, respectively) are not significantly different while *S. barbata* shows different N values (% 0.9) from the two other species. N content in litter of three species is different so that *S.rigida* and *S. barbata* litters contain the largest and smallest N, respectively (Fig. 1). Percentage of N in underground parts of *S. rigida* is the highest (% 1.1) which is significantly different from two other species (Fig. 1).

Meanwhile, Figure 2 shows that aerial parts of *A. sieberi* include the highest K content (1200 ppm) compared to *S. barbata* (800 ppm) and *S. rigida* (1000 ppm). This trend was observed for underground K content values, as well. With regard to K content in litter, *S. barbata* and *A. sieberi* are similar (300 ppm) while their K amount is two times higher than that of *S. rigida* (150 ppm).

Table 1. F values of N, P, K and OC in different parts of understudy species

Properties	S.O.V	df	MS	F	Sig
Shoot N (%)	Between groups Within groups	2 15	0.145 0.014	10.105	0.002 **
Litter N (%)	Between groups Within groups	2 15	0.376 0.026	13.876	0.000 **
Root N (%)	Between groups Within groups	2 15	0.094 0.017	5.421	0.017 *
Shoot P (ppm)	Between groups Within groups	2 15	4.054 0.857	4.731	0.026 *
Litter P (ppm)	Between groups Within groups	2 15	0.803 0.087	9.22	0.002 **
Root P (ppm)	Between groups Within groups	2 15	0.014 0.927	0.015	0.976 n.s
Shoot K (ppm)	Between groups Within groups	2 15	428672.222 63307.778	6.771	0.008 **
Litter K (ppm)	Between groups Within groups	2 15	10443.5 2479.883	4.211	0.035 *
Root K (ppm)	Between groups Within groups	2 15	260438.889 5646.667	46.123	0.000 **
Shoot OC (%)	Between groups Within groups	2 15	225.998 2.441	92.596	0.000 **
Litter OC (%)	Between groups Within groups	2 15	56.996 0.931	61.217	0.000 **
Root OC (%)	Between groups Within groups	2 15	166.865 5.035	33.138	0.000 **

***: Significant difference at 1% level   *: Significant difference at 5% level   ns: non-significant difference*

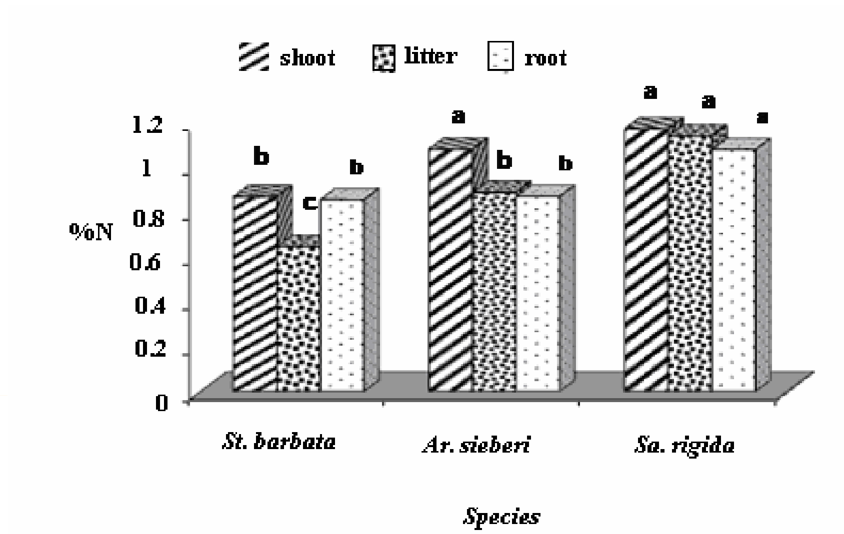

Fig 1. Comparing N percentage in root, shoot and litter of three species (similar letters show no significant difference)

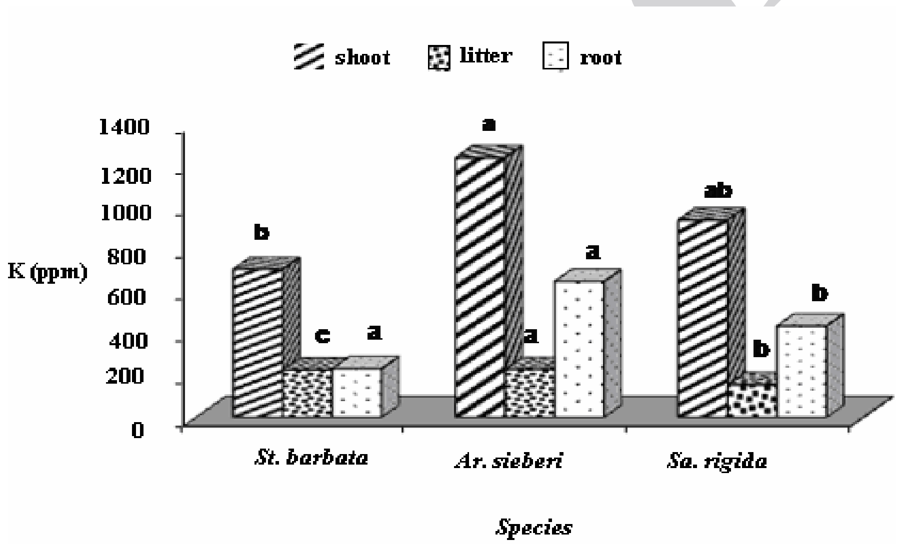

Fig 2. Comparing K amount in root, shoot and litter of three species (similar letters show no significant difference)

Approximately, the same trend for K was repeated for P in the species and their aerial parts while no significant difference was considered for their underground tissues. Based on litter P, *A. sieberi* with 2.6 ppm and *S.rigida* with 2.5 ppm, were not significantly different. P amount in litter *of S. barbata* (1.8 ppm) is the lowest among the three species. *S. rigida* possesses the highest amounts of organic carbon (OC) in different parts of the species except in the underground part, for which the highest OC percentage was recorded in *S. barbata*. The difference between litter OC of *S. barbata* (20%), *S. rigida* (12%) and *A. sieberi* (8%) is easily distinguished (Figs. 3, 4). C/N ratio is a suitable indicator to clear a species residues state in terms of their decomposition speed. Normally, smaller ratio is referred to as better C/N ratio when two species are compared. Figure 5 shows that different parts of *A. sieberi* have smaller C/N ratios. Although its aerial parts and litter C/N ratios are not significantly different with those of *S. barbata*. Additionally, C/N ratio of litter in *A. sieberi* is the same as that in *S. rigida.*

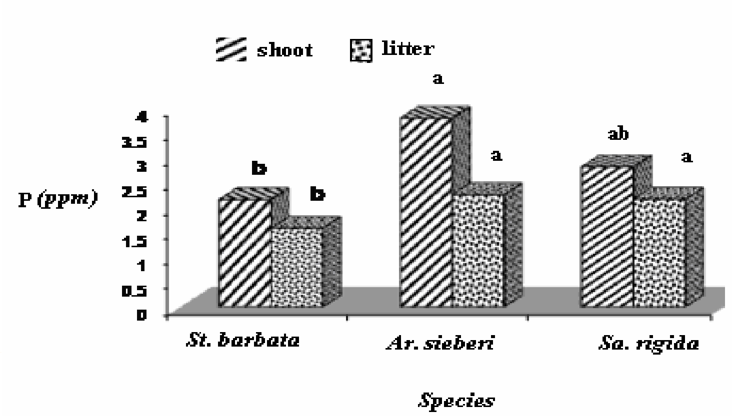

Fig 3. Comparing p amount in root, shoot and litter of three species (similar letters show no significant difference)

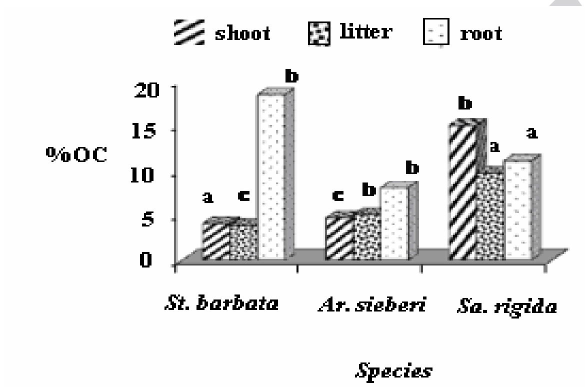

Fig 4. Comparing OC percentage in root, shoot and litter of three species (similar letters show no significant difference)

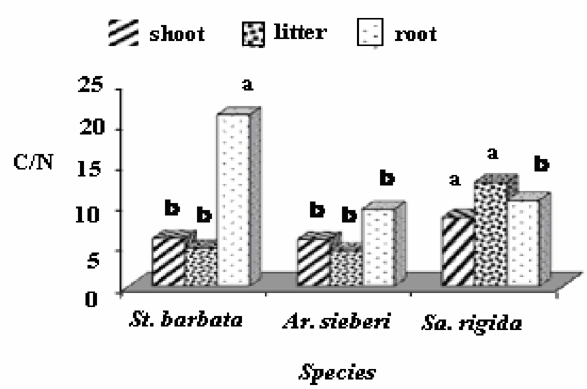

Fig 5. Comparing C/N ratio in root, shoot and litter of three species (similar letters show no significant difference)

Soil chemical properties

Based on ANOVA no significant differences were detected for soil characteristics, except for N and K, between soil samples collected from beneath *A. sieberi* and *S. rigida* at depths 0-20 cm and samples collected from the adjacent control area (bare soil with no plant) (Table 2). Similarly significant differences were observed for K value at 20-50 cm depth between *S. barbata* habitat and its control area (Table 3). Comparison of C/N ratio among soils of three species under study indicates that the highest and lowest C/N ratio at depth 0-20 cm are related to *S. barbata* (7) and *A. sieberi* (5.6), respectively. At depth 20-50 cm like depth 0-20 cm the lowest C/N ratio was related to *A. sieberi* (3.75) while the highest ratio was recorded for *S. barbata* (4.75). Data on chemical properties for the plants studied is presented in Table 4.

Table 2. F values of N, P, K and OC for taken samples beneath two species of *A. sieberi and S. rigida* and the adjacent control area

Properties	S.O.V	df	MS	F	Sig
%OC 1	Between groups Within groups	2 15	0.027 0.013	2.124	0.154 n.s
%OC 2	Between groups Within groups	2 15	0.02 0.011	1.864	0.189 n.s
%N 1	Between groups Within groups	2 15	0.00 0.00	12.314	0.001 **
%N 2	Between groups Within groups	2 15	0.00 0.00	0.273	0.765 n.s
P 1 ppm	Between groups Within groups	2 15	14.486 12.873	1.125	0.350 n.s
P 2 ppm	Between groups Within groups	2 15	10.143 6.007	1.688	0.218 n.s
K 1 ppm	Between groups Within groups	2 15	28066.667 3671.111	7.684	0.005 *
K 2 ppm	Between groups Within groups	2 15	9800.00 3653.333	2.682	0.101 n.s

**: Significant difference at 1% level *: Significant difference at 5% level
n.s: non-significant difference Depth 1: 0-20 cm Depth 2: 20-50 cm

Table 3. F values of N, P, K and OC of the soil properties beneath *St. barbata* in understudy area and blank sample

Properties	Treatment	***SE* ±average**	**df**	**t value**	**sig**
%OC 1	Soil beneath blank	0.342±0.0509 0.3375±0.0861	**10**	**0.047**	**0.964** n.s
%OC 2	Soil beneath blank	0.1955±0.0333 0.2197 ±0.0559	**10**	**-0.371**	**0.718** n.s
%N 1	Soil beneath blank	0.0502±0.0031 0.0524±0.00205	**10**	**-0.572**	**0.58** n.s
%N 2	Soil beneath blank	0.0402±0.00217 0.0427±0.0218	**10**	**-0.833**	**0.424** n.s
P 1 ppm	Soil beneath blank	13.859±1.4781 13.1563±0.7295	**10**	**0.426**	**0.679** n.s
P 2 ppm	Soil beneath blank	8.1282±0.6392 9.1187±0.5812	**10**	**-1.146**	**0.278** n.s
K 1 ppm	Soil beneath blank	313.333±31.693 373.333±36.7574	**10**	**-0.236**	**0.245** n.s
K 2 ppm	Soil beneath blank	206.6667±16.0555 276.6667±15.8464	**10**	**-3.103**	**0.011** *

**: Significant dif1ference at 1% level *: Significant difference at 5% level
n.s: non-significant difference Depth 1 : **0-20 cm** Depth 2 : **20-50 cm**

Table 4. Different properties of three species in different parts of the plants

Species / *Property*	*St.barbata*	*A.sieberi*	*S.rigida*
Litter C/N	5.92	5.76	8.5
Shoot C/N	4.7	4.35	12.8
Root C/N	21.17	9.48	10.6
Shoot N, P,K	N= 0.78 P= 2.15 K = 706.66	N=1.08 P =3.79 K= 1240	N=1.17 P= 2.81 K= 941.6
Litter N,P,K	N= 0.65 P=1.58 K=226.66	N= 0.88 P= 2.25 K= 226.1	N=1.14 P=2.16 K= 154.6
Root N,P,K	N= 0.87 P= 2.61 K =231.6	N= 0.85 P= 2.61 K= 64.8	N= 1.08 P= 2.65 K= 436.6

DISCUSSION AND CONCLUSION

Soil organic carbon (OC) is important due to its role in providing energy and plant production for heterotrophic microorganisms (Puget, 2001). On the other hand, litter decomposition and mineralization of soil organic matter are closely related processes involved in global C and nutrient cycling (Lambers *et al*., 1998). According to the results, the highest value of OC was related to the aerial parts and litter of *S. rigida* and *S. barbata* underground tissues. However, greater OC in underground parts of *S. barbata* compared to *S. rigida* and *A. sieberi* might be related to the massive and clumped roots. Salardini (2003) states that higher plant density leads to more roots which in turn results in more organic matter. It was revealed that OC of roots is higher than that in litter and aerial parts.

On the other hand, N content of litter in *S. rigida* was higher than the rest of the features. Totally, N content of litter in three species was higher than in other two parts. The results of other researchers such as Charley and Cowling (1967), Romney *et al*. (1974), Constanitides and Fownes (1994), Jafari and Rahimzadeh (2004) and Hajibaglu (2006) verify that litter N is higher than other parts. As apparent in the results, shoot N of *A. sieberi* was significantly different from that of *S. barbata.* Also, a similar trend could be considered for litter N. Carreara (2005) found that evergreen shrubs usually produce N-rich leaf litter with high concentration of secondary compounds compared to perennial grasses. Higher N of *S. rigida* litter compared to other species could be related to its leaf/stem ratio. Koukoura *et al.* (2003) explain that plant leaves contain larger amount of N compared to the stem. It is suggested that larger amount of N in *S. rigida* underground tissues compared to other species is due to its deeper and denser roots.

Higher K in aerial parts of *A. sieberi* could be related to recycle of K in plant branches (shoots) before they fall beneath the plant. This is a conservative approach in plants (Salardini, 2003). Also it has been found that cations leave the decomposition environment faster than anions (Blair, 1998). Findings of Charley and Cowling (1967), Romney and Wallace (1974), Rauzi (1975), and Hajibaglu (2006) emphasize that shoot K value is higher than root and litter. Since K does not participate in structure of litter and is washed easily, hence its amount is less than what root and shoot contain. Decomposition rate mostly depends on C/N ratio, that is, lower the ratio, higher the decomposition speed (Saleh Rastin, 1996). Adams and Attiwill (1986) state that organic matter with high C/N or lignin/N ratios decomposes at relatively low rates and induces low rates of N mineralization, high N immobilization in microbial biomass, minimal nitrification and prevalence of ammonification. Moretto and Distel (1997) show that leaves of the palatable grasses are higher in N concentration while lower in C/N ratio and lignin concentration than those of the unpalatable grasses. C/N ratio of *A. sieberi* litter is smaller than that of *S. barbata* and *S. rigida*. This means that *A. sieberi* litter will be decomposed faster than the latter plants. Totally, based on the results obtained from this research, it seems that *A. sieberi*, with regard to its decomposition property, could be considered as a suitable plant to use in vegetation cover development projects.

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بررسی و مقایسه خصوصیات شیمیایی ریشه، شاخه و لاشبرگ سه گونه مرتعی

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چکیده:

گونه های مرتعی کشت شده در یک منطقه می توانند موجب بروز تاثیرات مثبت یا منفی در خصوصیات منطقه گردند که این ویژگیها از بسیاری جهات ارتباط مستقیمی با خصوصیات شیمیایی ریشه ، شاخه و لاشبرگ دارند. بنابراین شناخت این خصوصیات در گونه های شاخص مرتعی که در پروژه های احیا و اصلاح مراتع مورد استفاده قرار می گیرند می تواند بسیار مهم و حیاتی باشد. در این تحقیق خصوصیات شیمیایی ریشه ،شاخه و لاشبرگ سه گونه مهم مرتعی در ایران شامل *Salsola rigida, Artemisia sieberi Stipa barbata* مورد مطالعه و مقایسه قرار گرفت. بدین منظورتیپ های رویشی *Salsola rigida, Artemisia sieberi Stipa barbata* درمراتع منطقه زرند ساوه انتخاب گردید و در داخل هر تیپ ۳۰ نمونه از ریشه، شاخه و لاشبرگ هر گونه مرتعی برداشت شد. سپس نمونه های برداشت شده مورد تجزیه شیمیایی قرار گرفت و مواردی نظیر N, P, K, C وC/N در آنها تعیین گردید. نتایج اندازه گیری ها نشان داد که بیشترین و کمترین مقدار C/N مربوط به ریشه *Stipa barbata* و شاخه *Artemisia sieberi* می باشد. همچنین این بررسی نشان داد که مقادیر N و P در *Stipa barbata* کمترین مقدار بین سه گونه مورد بررسی بوده در حالی که شاخه های *Artemisia sieberi and Salsola rigida* بیشترین مقادیر N و P را دارا بودند. همچنین لاشبرگ *Salsola rigida* و شاخه های *Artemisia sieberi* به ترتیب کمترین و بیشترین مقادیر K را دارا بودند. بطور کلی دانستن این ویژگیهای شیمیایی در گیاهان مرتعی می تواند کمک موثری به یافتن راه حل های مناسب تر جهت اجرای صحیح تر پروژه های احیای مراتع ایران داشته باشد.