

Impact of Dominant Shrub Species on Soil Organic Matter Content in Dry Grassland Habitats

Reza Erfanzadeh^{1*}, Behnam Bahrami², Javad Motamedi³, Ghasem Ali Dianati Tilaki¹
and Mehdi Abedi⁴

¹ Associate Professor, Department of Rangeland Management, Faculty of Natural Resources, Tarbiat Modares University, Noor, Iran

² MSc. Student, Department of Rangeland Management, Faculty of Natural Resources, Tarbiat Modares University, Noor, Iran

³ Assistant Professor, Department of Rangeland Management, Faculty of Natural Resources and Agriculture, Urmia University, Urmia, Iran

⁴ Assistant Professor, Department of Rangeland Management, Faculty of Natural Resources, Tarbiat Modares University, Noor, Iran

Received: 13 January 2016 / Accepted: 1 April 2016 / Published Online: 1 July 2016

ABSTRACT The effects of dominant shrub species on soil organic matter (SOM), including total soil carbon (SC), total nitrogen (N) and particulate organic matter (POM) were compared in three stands differing in the type of shrub species, i.e. *Astragalus microcephalus* (shrub), *Pteropyrum aucheri* (shrub) and *Prangus uloptera* (non-shrub). The stands were located in arid grasslands of north-western Iran. For this purpose, 18 soil samples from each stand were systematic-randomly collected (by auger) from each depth of 0-15cm and 15-30cm, along 6 transect in each stand. The results showed that the stands with the highest abundance of *P. aucheri* and *A. microcephalus* had the highest values for SC (0.99% and 0.98%) in both depths, and the highest values for N (0.13% and 0.12%), respectively. The highest POM percentage for carbon (0.24%) and nitrogen (0.03%) were observed in the stands with the highest abundance of *A. microcephalus*. The proportion of micro-aggregates (28.48%) was significantly higher than macro-aggregates (20.46%) in the upper soil layer of the stand with the highest abundance of *A. microcephalus* as compared to the others, while no significant difference detected in micro- and macro-aggregate contents of the lower soil layer between the stands. Therefore, the type of shrub species in the grassland communities had important effect on soil organic matter.

Key words: Grasslands, Shrub invasion, Soil organic carbon, Vegetation type

1 INTRODUCTION

Grasslands are globally important for soil organic matter (SOM) and carbon (C) sequestration, contributing more than 10 percent to the total biosphere carbon store (Scurlock and Hall, 1998; Abberton *et al.*,

2010). Altered management practices, land use change and climate changes not only strongly influence on grasslands structure, but may also potentially alter ecosystem function, including C sequestration and total nitrogen (N) (Guo and Gifford, 2002; Jones and Donnelly, 2004).

* correspondence author: Associate Professor, Department of Rangeland Management, Faculty of Natural Resources, Tarbiat Modares University, Noor, Iran, Tel: +98 937 318 1169, E-mail: rezaerfanzadeh@modares.ac.ir

The magnitude of SOM has been shown to be influenced by grassland vegetation types as well as by the specific plant (Jones and Donnelly, 2004). In addition, within the same plant communities, plant compositions can result in different SOM characteristics (Chatzitheodo Ridis, 2011; Medina-Roldán *et al.*, 2013; Erfanzadeh *et al.*, 2014). This might suggest that SOM is impacted by parameters like plant diversity and functional composition. Indeed, the significant relationship between vegetation characteristics and soil qualitative factors has been reported in several studies (e.g., Fornara and Tilman, 2008; Steinbeiss *et al.*, 2008; De Deyn *et al.*, 2009; Fornara *et al.*, 2009). However, understanding of the role of the type of dominant shrub(s) in soil N and C storage is still limited.

The encroachment of woody plants into grasslands has been widely reported as a global phenomenon and is one of the major changes in plant functional composition (Van Auken, 2000; Maestre *et al.*, 2009). Several factors including overgrazing, increases in atmospheric CO₂ and fire frequency could be considered as driver of shrub encroachment in grasslands (Bond and Midgley, 2000; Briggs *et al.*, 2005; Knapp *et al.*, 2008; Archer, 2010). It is well known that shrubland is one of the major types of terrestrial ecosystems which hold large stores of vegetation carbon due to its shrubs and woody species. Therefore, shrub invasion can increase soil C and N of grasslands (Bardgett *et al.*, 2005; Liao *et al.*, 2006; McClaran *et al.*, 2008; Springsteen *et al.*, 2010; Eldridge *et al.*, 2011). However, studies on the relationship between labile SOM and the species type of woody plants in natural grasslands are scarce (Six *et al.*, 1998; Finzi *et al.*, 1998; Hagen-Thorn *et al.*, 2004).

Shrubs, depending on the species, can strongly influence habitat conditions (She *et al.*, 2015). Therefore, this study was conducted to

investigate the impacts of shrub encroachment on SOM of three stands. The stands were different in the levels of abundance of two shrubs according to their shrub cover, representing a stand, more or less without shrubs and two other stands with dominance of one shrub species in each. The study aimed at evaluation of changes in soil C and N, when shrubs composition is varied between stands. It was hypothesized that variation in SOM values assigned to certain grassland type were in part due to variable shrub composition at different sampling stands. More precisely, it was hypothesized that different shrub species could determine the total amount of C and N in soil.

2 MATERIALS AND METHODS

2.1 Study area

The study was conducted in Khanghah watershed (37°46'18"N to 37°50'42"N and 44°57'04"E to 45°00'32"E). Mean annual precipitation and temperature are 393.9mm and 9.87°C, respectively (Fig. 1).

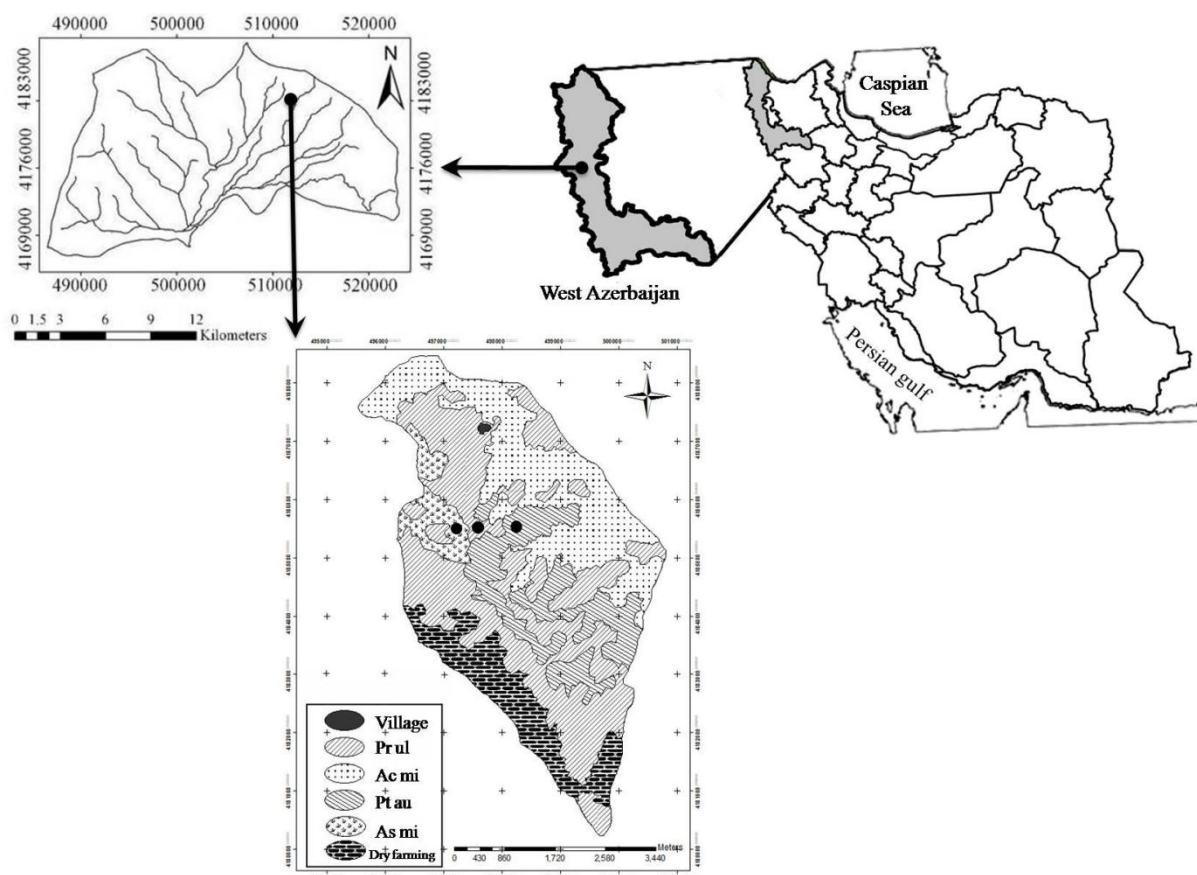


Fig 1. The study area within Khanghah watershed located in West Azarbaijan province with at least three stands

Three stands with similar climatological and topographical conditions were selected according to their (non-) shrub abundances, including *Astragalus microcephalus* (shrub), *Pteropyrum aucheri* (shrub) and *Prangus uloptera* (non-shrub). The stands were distinguished according to the dominant plant species (Heady and Child, 1994). All stands were classified as “good” for rangeland condition and “stable” for rangeland trend according to Holechek’s (1989) method. According to Motamedi (2009), the three species were observed in all stands with the highest abundance in one species (dominant species) in each stand (Appendix 1). In other words, in each stand, one of the aforesaid species was dominant and co-dominant species were more or less the same in all three stands.

This provides an opportunity to compare soil characteristics of the stands, and the differences could be related to differences in the type of dominant plant species. Hereafter, the stands are called according to the dominant plant species, i.e. *A. microcephalus* stand, *P. aucheri* stand and *P. uloptera* stand. There were two dominant species in *A. microcephalus* stand, i.e. *A. mrcrocephalus* and *Acanthophyllum microcephalum*, respectively, with 11.43 and 6.46 cover percentages. The data of an earlier study (Motamedi, 2009) was used to separate vegetation functional groups according to their cover percentage (Table 1). Each functional group is a summation of cover percentage of plant species, which is related to that functional group.

Table 1 Cover percentage (abundance) of plant functional groups in the three stands

Functional groups / type of shrub species level	<i>A. microcephalus</i>	<i>P. aucheri</i>	<i>P. uloptera</i>
Annuals	8.63	8.10	8.07
Perennial forbs	4.93	4.29	24.48
Perennial grasses	2.50	1.87	7.01
Shrub functional groups			
Shrubs	1.66	23.21	0.17
Cushion half-shrubs	6.46	0.65	0.59
Dwarf half-shrubs	4.19	3.87	4.75
Legumes half-shrubs	11.53	1.48	2.04

2.2 Vegetation and Soil sampling

Soil samples from each stand were collected from depths of 0 to 15cm and 15 to 30cm during spring 2011. These sampling depths are in accordance with the highest presence of root biomass in the grasslands (Reeder *et al.*, 2001). Based on an earlier study (Motamedi, 2009), six transects were randomly established in each stand; along each transect, three 4m×4m quadrats were established at the two ends and in the middle of each transect (Akhani *et al.*, 2013; Erfanzadeh *et al.*, 2014a). With an auger (diameter: 5cm), 10 soil cores were collected at random to a depth of 30cm in the quadrates. Each core was divided into two sub-cores (0-10 and 10-30cm) and sub-cores were then combined per depth for each quadrat (10 soil sub-cores mixed for each depth separately and two soil samples were created for each quadrat). All soil samples were immediately transferred to the laboratory and were stored at 4°C until processing. The samples were sieved, the roots and coarse gravel (>5mm) were removed, and the remaining was used to examine the effects of vegetation composition (dominant shrub) on soil parameters.

2.3 Soil and data analysis

Organic C was determined by loss on ignition in 600°C, 4 h (Lal *et al.*, 2001) and the total soil N was assessed using the Kjeldahl method (Zagal *et al.*, 2009). POM-C (particulate

organic matter for C) and POM-N (particulate organic matter for N) were determined by physical fractionation (Handayani *et al.*, 2009). Twenty-five grams of air-dried soil were dispersed with 100 ml of 5 g/l of sodium hexametaphosphate. The soil solution mixture was shaken for 1 h at high speed on an end-to-end shaker and poured over a 0.053 mm sieve with several deionised water rinses. The soil remaining on the sieve was back washed into a pre-weighed aluminium dish, then dried at 60°C for 24 h, ground and analysed for C and N (Handayani *et al.*, 2009).

In addition, organic C was measured in micro- and macro-aggregates. Therefore, aggregate size distribution (micro- and macro-aggregates) was determined using wet sieving with screen diameters of 0.25 and 0.50 mm. The ranges of micro-aggregates and macro-aggregates were between 0.053 to 0.25 mm and 0.25 to 0.50 mm, respectively. Soils were submersed in water on the largest screen for 5 min before sieving under water by gently moving the sieve 3 cm vertically 50 times over period of 2 min through water contained in a shallow pan. Material remaining on the sieve was transferred to an aluminium container and dried at 60°C in a forced-air oven, then weighed and measured for C (Elliott and Cambardella, 1991). Organic C in macro- and micro-aggregates was determined by the methodology of Lal *et al.* (2001) as well (N was not

measured in the aggregates due to the continuous error of Kjeldahl apparatus).

General linear model (two-way ANOVA) and post-hoc tests (LSD test) were used to compare the soil parameters between the stands and depths. Each soil parameter was considered as a dependent variable, while depth categories (0-15cm, 15-30cm and 0-30cm: the mean value of two upper and lower soil layers was allocated for 0-30cm depth) and the three stands were considered as fixed factors. An interaction between depth and stand was also considered in the model. Normal distribution of each variable was checked with the Kolmogorov-Smirnov test and Levene test was used to check for homogeneity of variance. All statistical analyses were done using SPSS v.17.

3 RESULTS

The two-way ANOVA results revealed that main factors ('stand' and 'soil depth') and their

interactions had significant effects on SOM parameters (Table 2). According to their F-values, 'stand' was the strongest factor influencing SOM. Although 'soil depth' had a significant effect on SOM, too, its effect was less pronounced than that of type of shrub species level (Table 2).

3.1 Soil and data analysis

Total C in both of 0-15cm and 15-30cm soil depths and also in 0-30cm as pooled depth was highest for *A. microcephalus* and *P. aucheri* stands and lowest for *P. uloptera* stand (Figure 2A and Table 2). Total N in all layers, including pooled, lower and upper depths were highest in the stand with the highest abundance in *A. microcephalus* and lowest in the stand with highest abundance in *P. uloptera* (Figure 2B; Table 2).

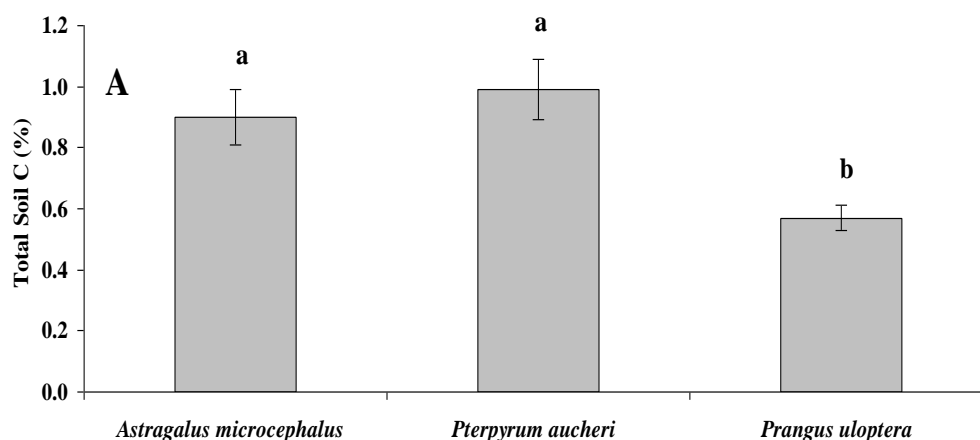


Figure 2 Total C (A) and total N (B) in the pooled 0-30cm depth in the three stands (the error bars show SE). Different letters indicate significant differences ($P = 0.05$) between the three stands.

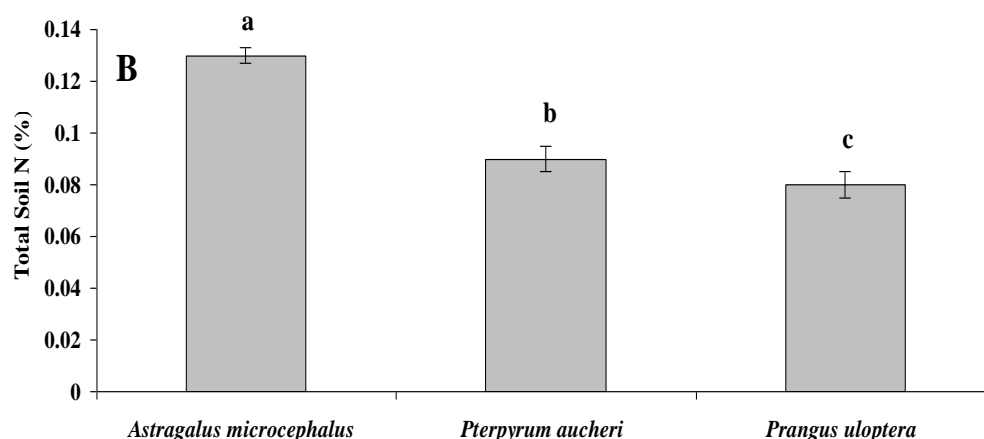


Figure 2 Continued

Table 2 Main soil organic matter fraction and aggregate distribution (mean \pm SE) in the 0-5 and 15-30cm soil layers for *A. microcephalus* stand compared to *P. aucheri* and *P. uloptera* stands in the grasslands, north-western Iran

Depth (cm)	Stand	SOC (%)	TN (%)	POMC (%)	POMN (%)	Macro-aggregates (%)	Micro-aggregates (%)	CMAC (%)	CMIC (%)
0-15	<i>A. microcephalus</i>	0.97 \pm 0.05a	0.13 \pm 0.004a	0.29 \pm 0.017a	0.03 \pm 0.002a	20.46 \pm 1.15b	28.48 \pm 1.33a	1.42 \pm 0.157a	1.62 \pm 0.080a
	<i>P. aucheri</i>	0.98 \pm 0.04a	0.09 \pm 0.009b	0.18 \pm 0.060b	0.03 \pm 0.001a	34.63 \pm 2.11a	20.34 \pm 1.90b	1.14 \pm 0.143a	1.76 \pm 0.075a
	<i>P. uloptera</i>	0.65 \pm 0.01b	0.08 \pm 0.009b	0.16 \pm 0.069b	0.02 \pm 0.003b	33.42 \pm 2.13a	23.94 \pm 2.38ab	0.69 \pm 0.103b	1.20 \pm 0.040b
15-30	<i>A. microcephalus</i>	0.83 \pm 0.043a	0.12 \pm 0.005a	0.19 \pm 0.001a	0.03 \pm 0.001a	33.2 \pm 0.40a	21.20 \pm 0.66a	1.14 \pm 0.054a	1.54 \pm 0.040a
	<i>P. aucheri</i>	0.99 \pm 0.042a	0.09 \pm 0.007b	0.10 \pm 0.014b	0.02 \pm 0.001a	35.7 \pm 1.09a	17.67 \pm 0.89a	0.77 \pm 0.069b	1.37 \pm 0.061b
	<i>P. uloptera</i>	0.50 \pm 0.033b	0.07 \pm 0.006c	0.11 \pm 0.012b	0.01 \pm 0.002b	35.4 \pm 1.21a	21.11 \pm 0.74a	0.38 \pm 0.029c	1.070.7 \pm 0.025c
Two-way ANOVA results (mean squares)									
Stand (C)		1.871**	0.025**	0.138**	0.003**	842.788**	342.856**	25.751**	2.567**
Depth (D)		0.273 ^{ns}	0.002 ^{ns}	0.178**	0.003**	838.612**	548.303**	14.322**	1.177**
CxD		0.089 ^{ns}	0.000 ^{ns}	0.007 ^{ns}	6.445 ^{ns}	425.812*	70.014 ^{ns}	0.084 ^{ns}	0.265*

SOC, soil organic carbon; TN, total nitrogen; POMC, particulate organic matter carbon; POMN, particulate organic nitrogen; CMAC, carbon in macro-aggregates; CMIC, carbon in micro-aggregates; ns, not significant. * $P < 0.05$; ** $P < 0.01$; within a column mean values with different letters, a), b) and c), in each soil depth are significantly different between stands at $P < 0.05$ (Duncan's test at $\alpha = 0.05$)

3.2 Labile SOM fractions

Soil POM-C and also POM-N were generally highest in the stand with the highest abundance in *A. microcephalus* (Figure 3A and Figure 3B).

POM-C contents in the *A. microcephalus*, *P. aucheri*, and *P. uloptera* stands were 0.29 %, 0.18 % and 0.16 %, respectively, in the upper soil layer. POM-C content in the stand with the

highest abundance in *A. microcephalus* was 0.19 % in the deeper soil layer, which was significantly higher than the *P. aucheri* and *P. uloptera* stands. POM-N contents in both

depths for the *A. microcephalus* and *P. aucheri* stands were significantly higher than that for the *P. uloptera* stand (Table 2).

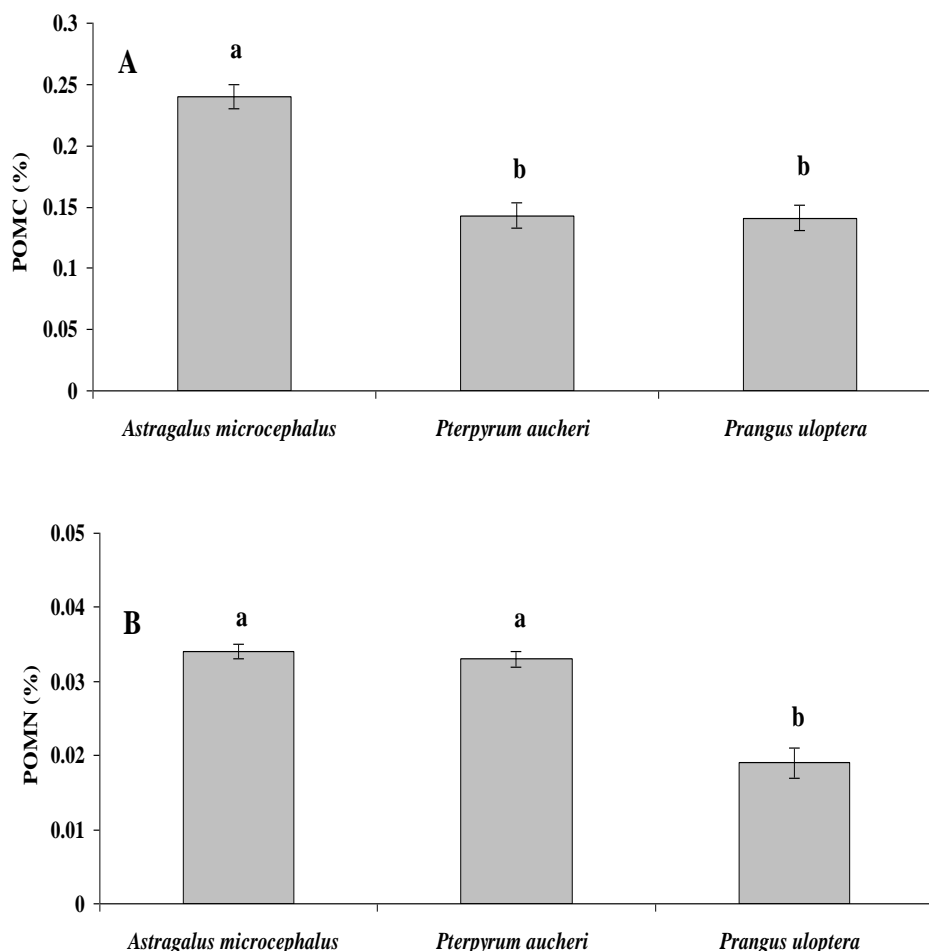


Figure 3 particulate organic matters for carbon (A) and for nitrogen (B) in the pooled 0-30cm depth in three stands (the error bars show SE). Different letters indicate significant differences ($P < 0.05$) between the stands

3.3 Aggregate distribution and carbon associated with aggregate size classes

There was a significantly smaller proportion of soil present as macro-aggregates in the stand with the highest abundance in *A. microcephalus* compared to the stands with the highest abundance in *P. uloptera* and *P. aucheri* in the upper soil layer, but differences in macro-aggregates were not significant in the lower soil layer (Table 2). Significantly a higher

proportion of soil was present as micro-aggregates in both the stands with the highest abundance in *A. microcephalus* and *P. uloptera* as compared to the stand with the highest abundance in *P. aucheri* in the upper soil layer; no significant difference was evident in the proportions of micro-aggregates in the lower soil layer (Table 2).

Carbon content was significantly greater for each type of aggregate in the stands with the

highest abundance in *A. microcephalus* and *P. aucheri* than the stand with the highest abundance in *P. uloptera* in the upper soil layer (Table 2). Carbon content was significantly highest for both types of aggregate in the stand with the highest abundance in *A. microcephalus* and lowest in the stand with the highest abundance in *P. uloptera* in the deeper soil layer (Table 2).

4 DISCUSSION

A decline in the amount of organic inputs from plants to soil occurs in Iran and other areas with an arid and semiarid climate as a result of low rainfall and high air temperature (Kabiri *et al.*, 2015). Therefore, we need to manage the natural habitat so that higher SOM enter into soil. At the first step, studies about the spatial variation of SOM and the effect of the above-ground vegetation on OM input to soil should be conducted. Therefore, the aim of this study was to explore the impact of different plant functional compositions on SOM in three different stands. Generally, we found that not only the total cover of shrub but also the type of shrub species could determine the total C and N in the soil. Although some earlier studies showed that soil characteristics can affect vegetation type and regulate floristic composition (e.g. Li *et al.*, 2015), vegetation characteristics can also affect soil parameters. Results of this study showed that N, TC, POM-C and POM-N were significantly higher in the stand with dominance of cover of *A. microcephalus*. We suggest that the species of the plant coverage (mostly shrubs) are responsible for this variation. Influence of the above-ground vegetation through different cultivations has been considered in several studies (Luan *et al.*, 2010; Ontl *et al.*, 2015). However, in natural and non-cultivated grasslands mainly vegetation types play the major role on soil properties (Oueslati *et al.*, 2013). In the current study, the spatial variation

of SOM in the habitats was found affected by the shrub species as well. The SOM content generally increased with developing shrubs in the study area. This confirms that under natural conditions not only management attributes (Pulido-Fernández *et al.*, 2013), but also vegetation factors define soil SOM as follows:

4.1 Shrub functional compositions

Based on the earlier findings that vegetation would control the spatial variability of SOM (McClaran *et al.*, 2008; Eldridge *et al.*, 2011; Oueslati *et al.*, 2013), we tried to explain our results according to the dominant species in each site (stand). In *P. uloptera* stand, vegetation was observed with high participation of perennial forbs. In *A. microcephalus* stand, half-shrub legumes and half-shrub cushion (*Acanthophyllum microcephalum*) were dominant as compare to the *P. aucheri* stand with mainly open canopy shrub (Table 1). These functional compositions lead to different SOM values. Firstly, high SOM values (in the intact soil and aggregates) in the *A. microcephalus* stand show that their dominant functional compositions, including half-shrub legumes and half-shrub cushions, can accumulate high C-levels in the soil. These results are consistent with studies that show woody plants accumulate better soil organic matter in both natural and artificial habitats (McClaran *et al.*, 2008; Fornara and Tilman 2008; Liu *et al.*, 2013; de Oliveira *et al.*, 2015). These functional groups may also positively influence grassland function as so-called "fertile island" (Li *et al.*, 2007). Cushion species (e.g., *A. microcephalum*) produce small spiny stems, which tend to die back almost to the base after the growing season each year. Indeed, litter accumulation beneath woody plants in the grasslands is a common phenomenon and provides opportunities for carbon and nitrogen sequestration (e.g., Jackson *et al.*, 2002). The effect of fertile island on

some other soil properties (e.g. soil seed bank) was previously reported (e.g. Erfanzadeh *et al.*, 2014b). In addition, planting of woody species increased vegetation carbon storage, carbon density and carbon sequestration rate in Northeast China (Zhen *et al.*, 2014). Since the species with the highest proportion of canopy cover in the *A. microcephalus* stand was the leguminous *A. microcephalus*, which is a deciduous shrub growing to 0.5 m. This species has a symbiotic relationship with certain soil bacteria, which form nodules on roots and fix atmospheric nitrogen (Erfanzadeh *et al.*, 2014a). As a result, in the *A. microcephalus* stand, legume-shrub associated rhizobia fixing N₂ may increase the total N in soils of this stand as well. Furthermore, the *P. aucheri* stand has lower N and non-significantly higher C than the *A. microcephalus* stand. The open canopy shrub as the main species of this stand probably has lower ability to maintain litter and resources under its canopy than cushions and legumes half-shrubs types. This result is consistent with the ones that show the open canopy shrubs have low potential for resources capture and nutrient cycling (Abedi *et al.*, 2006; Toranjzaret *et al.*, 2010). In addition, the open canopy shrubs have deep root systems with high participation of macro aggregate that leads to high available carbon in the soil. The total organic carbon and carbon in micro- and macro-aggregates and also labile fractions of SOM confirmed our hypothesis of dominant shrub species impacting on soil C- and N-relations. High values of POM-C and POM-N in two stands with a high percentage of shrub cover compared with the *p. uloptera* stand confirmed the role of shrubs in increasing of SOM. The change in vegetation from herbal species to woody species increased POM-C in topsoil (0-15cm depth) by 81.3%. At the same time, the total C in the upper layer was increased by 49.0%. By contrast, the variation range of the total N was higher than POM-N after a change in the vegetation from

herbal to woody composition. The composition of POM consisted mainly of root fragments (Hofle *et al.*, 2013). Thus, significantly different levels of POM-C and POM-N between the three communities in this study suggest differences in root biomass.

In the current study, the picture of total communities was considered and we tried to explain variation of SOM between grassland communities, including different shrub species. Classification of grasslands according to the type of shrub or shrub canopy shape (open or cushion), which affect litter and resources accumulation, root structure and aggregate conditions, for future interpretation of natural habitat is promising.

5 CONCLUSION

Considering the crucial role of soil C and N in sustaining soil quality, knowledge on the effects of the type of shrub species on SOM status is essential in natural habitats. The stock of soil C and N depends not only on the total cover of shrub but also the type of shrub species.

6 REFERENCES

- Akhani, H., Mahdavi, P., Noroozi, J. and Zarrinpour, V. Vegetation Patterns of the Irano-Turanian Steppe along a 3000m Altitudinal Gradient in the Alborz Mountains of Northern Iran. *Folia Geobot.* 2013; 48(2): 229-255.
- Abedi, M., Arzani, H, Shahriari, E., Tongway, D. and Aminzadeh, M. Assessment of patches structure and function in Arid and semi arid Rangeland. *J. Environ. Studies.* 2007; 40: 117-126 (In Persian).
- Abberton, M., Conant, R. and Batello C. Grassland carbon sequestration: management, policy and economics. *Food and Agriculture of the United Nations, Rome.* 2010; 342 P.

- Archer, S.R. Rangeland conservation and shrub encroachment: new perspectives on an old problem, wild rangelands: conserving wildlife while maintaining livestock in semi-arid ecosystems, 2010; 53 P.
- Bardgett, R.D., Bowman, W.D., Kaufmann, R. And Schmidt, S.K.A temporal approach to linking aboveground and belowground ecology. *Trends Ecol. Evol.*, 2005; 20(11): 634-641.
- Bond, W.J. and Midgley, G.F. A proposed CO₂-controlled mechanism of woody plant invasion in grasslands and savannas. *Glob. Change Biol.*, 2000; 6(8): 865-869.
- Briggs, J.M., Knapp, A.K., Blair, J.M., Heisler, J.L., Hoch, G.A., Lett, M.S. and McCarron, J.K. An ecosystem in transition: causes and consequences of the conversion of mesic grassland to shrubland. *Bioscience*. 2005; 55(3): 243-254.
- Burke, I.C., Lauenroth, W.K., Vinton, M.A., Hook, P.B., Kelly, R.H., Epstein, H.E., Aguiar, M.R., Robles, M.D., Aguilera, M.O. and Murphy, K.L. Plant-soil interactions in temperate grasslands, Plant-induced soil changes: Processes and feedbacks. Springer.1998; 121-143.
- Chatzitheodo Ridis, F. Soil property variations in relation to plant community and altitudinal zone in the rangelands of Epirus, Greece. *Bulg. J. Agr. Sci.*, 2011; 17(6): 806-815.
- deDeyn, G.B., Quirk, H., Yi, Z., Oakley, S., Ostle, N.J. and Bardgett, R.D. Vegetation composition promotes carbon and nitrogen storage in model grassland communities of contrasting soil fertility. *J. Ecol.*, 2009; 97(5): 864-875.
- de Oliveira, S.P., de Lacerda, N.B., Blum, S.C., Escobar, M.E.O., de Oliveira, T.S. Organic carbon and nitrogen stocks in soils of Northeastern Brazil converted to irrigated agriculture. *Land Degrad. Develop.*, 2015; 26: 9-21.
- Eldridge, D.J., Bowker, M.A., Maestre, F.T., Roger, E., Reynolds, J.F. and Whitford, W.G. Impacts of shrub encroachment on ecosystem structure and functioning: towards a global synthesis. *Ecol. Lett.*, 2011; 14(7): 709-722.
- Elliott, E. and Cambardella, C. Physical separation of soil organic matter. *Agr. Ecosys. Environ.*, 1991; 34: 407-419.
- Erfanzadeh, R., Bahrami, B., Motamedi, J. and Pétillon, J. Changes in soil organic matter driven by shifts in co-dominant plant species in a grassland. *Geoderma*. 2014a; 213: 74-78.
- Erfanzadeh, R., Shahbazian, R. and Zali, H. Role of plant patches in preserving flora from the soil seed bank in an overgrazed high-mountain habitat in northern Iran. *J. Agr. Sci. Tech*. 2014b; 16: 229-238.
- Finzi, A.C., Van Breemen, N. and Canham, C.D. Canopy tree-soil interactions within temperate forests: species effects on soil carbon and nitrogen. *Ecol. Appl.*, 1998; 8(2): 440-446.
- Fornara, D. and Tilman, D. Plant functional composition influences rates of soil carbon and nitrogen accumulation. *J. Ecol.*, 2008; 96(2): 314-322.
- Fornara, D.A., Tilman, D. and Hobbie, S.E. Linkages between plant functional composition, fine root processes and potential soil N mineralization rates. *J. Ecol.*, 2009; 97(1): 48-56.

- Guo, L. and Gifford, R. Soil carbon stocks and land use change: a meta analysis. *Glob. Change Biol.*, 2002; 8(4): 345-360.
- Hagen-Thorn, A., Callesen, I., Armolaitis, K., Nihlgård, B. The impact of six European tree species on the chemistry of mineral topsoil in forest plantations on former agricultural land. *Forest Ecol. Manag.*, 2004; 195(3): 373-384.
- Handayani, I.P., Coyne, M.S. and Tokosh, R.S. Soil organic matter fractions and aggregate distribution in response to tall fescue stands. *Int. J. Soil Sci.*, 2009; 5(1): 1-10.
- Heady, H.F. and Child, R.D. *Rangeland ecology and management*. Westview Press, Inc. 1994. 519 P.
- Hofle S., Rethemeyer, J., Mueller, C.W., and John S. Organic matter composition and stabilization in a polygonal tundra soil of the Lena Delta. *Biogeo.*, 2013; 10: 3145-3158.
- Holechek, J. L., *Range Management*. Prentice-Hall, Inc. USA. 1989. 501 P.
- Jackson, R.B., Banner, J.L., Jobbágy, E.G., Pockman, W.T. and Wall, D.H. Ecosystem carbon loss with woody plant invasion of grasslands. *Nature* 418(6898), 2002; 623-626.
- Jones, M.B. and Donnelly, A. Carbon sequestration in temperate grassland ecosystems and the influence of management, climate and elevated CO₂. *New Phytol.* 2004; 164(3): 423-439.
- Kabiri, V., Raiesi, F., Ghazavi, M.A. Six years of different tillage systems affected aggregate-associated SOM in a semi-arid loam soil from Central Iran. *Soil Till. Res.* 2015; 154: 114-125.
- Knapp, A.K., Briggs, J.M., Collins, S.L., Archer, S.R., Bret-Harte, M.S., Ewers, B.E., Peters, D.P., Young, D.R., Shaver, G.R. and Pendall, E. Shrub encroachment in North American grasslands: shifts in growth form dominance rapidly alters control of ecosystem carbon inputs. *Glob. Change Biol.*, 2008; 14(3): 615-623.
- Lal, R., Kimble, J.M., Follet, R.F. and Stewart, B.A. *Assessment methods for soil carbon*. CRC press. Boca Raton, FL. 2001; 696 P.
- Li, J.X., Xiong, G.M., Xu, W.T. and Zong-Qiang Xie, Z.Q. Distribution of shrublands in relation to soil and climate in mid-subtropical China. *J. Plant Ecol.*, 2015; 24: 125-157.
- Li, W.-J., Li, J.-H., Lu, J.-F., Zhang, R.Y. and Wang, G. Legume-grass species influence plant productivity and soil nitrogen during grassland succession in the eastern Tibet Plateau. *Appl. Soil Ecol.*, 2010; 44(2): 164-169.
- Li, J., Zhao, C., Zhu, H., Li, Y. and Wang, F. Effect of plant species on shrub fertile island at an oasis-desert ecotone in the South Junggar Basin, China. *J. Arid Envi.*, 2007; 71(4): 365-371.
- Liao, J.D., Boutton, T.W. and Jastrow, J.D. Storage and dynamics of carbon and nitrogen in soil physical fractions following woody plant invasion of grassland. *Soil Biol. Biochem.*, 2006; 38(11): 3184-3196.
- Liu, M.Y., Chang, Q.R., Qi, Y.B., Liu, J., Chen, T. Aggregation and soil organic carbon fractions under different land uses on the tableland of the Loess Plateau of China. *Catena*. 2014; 115: 19-28.

- Luan, J., Xiang, C., Liu, S., Luo, Z., Gong, Y. and Zhu, X. Assessments of the impacts of Chinese fir plantation and natural regenerated forest on soil organic matter quality at Longmen mountain, Sichuan, China. *Geoderma*, 2010; 156(3): 228-236.
- Maestre, F.T., Bowker, M.A., Puche, M.D., Belén Hinojosa, M., Martínez, I., García-Palacios, P., Castillo, A.P., Soliveres, S., Luzuriaga, A.L. and Sánchez, A.M. Shrub encroachment can reverse desertification in semi-arid Mediterranean grasslands. *Ecol. Lett.*, 2009; 12(9): 930-941.
- McClaran, M.P., Moore-Kucera, J., Martens, D.A., van Haren, J. and Marsh, S.E. Soil carbon and nitrogen in relation to shrub size and death in a semi-arid grassland. *Geoderma*. 2008; 145(1): 60-68.
- Medina-Roldán, E., Huber-Sannwald, E. and Arredondo, J.T. Plant phenotypic functional composition effects on soil processes in a semiarid grassland. *Soil Biol. Biochem.*, 2013; 66: 1-9.
- Motamedi, J. Feasibility and executive studies on vegetation in Khangah-e-Sorkh, Urmia University Press, Iran. 2009.
- Ontl, T.A., Cambardella, C.A., Schulte, L.A., Kolka, R.K. Factors influencing soil aggregation and particulate organic matter responses to bioenergy crops across a topographic gradient. *Geoderma*. 2015; 255: 1-11.
- Oueslati, I., Allamano, P., Bonifacio, E. and Claps, P. Vegetation and topographic control on spatial variability of soil organic carbon. *Pedosphere*. 2013; 23(1): 48-58.
- Pulido-Fernández, M., Schnabel, S., Lavado-Contador, J.F., Mellado, I.S., Pérez, R.O. Soil organic matter of Iberian open woodland rangelands as influenced by vegetation cover and land management. *Catena*. 2013; 109: 13-24.
- Reeder, J., Franks, C., Milchunas, D., Follett, R. and Kimble, J. Root biomass and microbial processes. In: R. Lal (Ed.), *The potential of U.S. grazing lands to sequester carbon and mitigate the greenhouse effect*. Lewis Publishers, Boca Raton, Florida. 2001; 139-166.
- Scurlock, J. and Hall, D. The global carbon sink: a grassland perspective. *Glob. Change Biol.*, 1998; 4(2): 229-233.
- She, W., Zhang, Y., Qin, S., Wu, B., Liu, Z., Liu, J., and Zhang, W. Habitat effect on allometry of a xeric shrub (*Artemisia ordosica* Krasch) in the Mu Us desert of Northern China. *Forests*, 2015; 6: 4529-4539.
- Six, J., Elliott, E., Paustian, K. and Doran, J. Aggregation and soil organic matter accumulation in cultivated and native grassland soils. *Soil Sci. Soc. A. J.*, 1998; 62(5): 1367-1377.
- Springsteen, A., Loya, W., Liebig, M. and Hendrickson, J. Soil carbon and nitrogen across a chronosequence of woody plant expansion in North Dakota. *Plant Soil*. 2010; 328(1-2): 369-379.
- Steinbeiss, S., Bebler, H., Engels, C., Temperton, V.M., Buchmann, N., Roscher, C., Kreuziger, Y., Baade, J., Habekost, M. and Gleixner, G. Plant diversity positively affects short-term soil carbon storage in experimental grasslands. *Glob. Change Biol.*, 2008; 14(12): 2937-2949.
- Toranjzar, H., Abedi, M., Ahmadi, A. and Ahmadi, Z. Assessment of rangeland

conditions (health) in Meyghan desert Arak. *Rangeland*.2009; 10: 259-271.

Van Auken, O. Shrub invasions of North American semiarid grasslands. *Annu. Rev. Ecol. Syst.*, 2000; 31: 197-215.

Zagal, E., Muñoz, C., Quiroz, M. and Córdova, C. Sensitivity of early indicators for evaluating quality changes in soil organic matter. *Geoderma*. 2009; 151(3): 191-198.

Zhen, W., Huang, M., Zhai, Y.L., Chen, K. and Gong Y.Z. Variation of forest vegetation carbon storage and carbon sequestration rate in Liaoning Province, Northeast China. *PubMed*. 2014; 25(5): 1259-1265.

Appendix 1 Cover percentage of species in each stand

Species	Functional groups	<i>Prangus uloptera</i> stand	<i>Astragalus microcephalus</i> stand	<i>Pteropyrum aucheri</i> stand
<i>Centaurea virgata</i> Lam.	Annual	0.19	0.57	0.22
<i>Cirsium arvense</i> (L.) Scop.	Annual	0	0	0.03
<i>Noaeamucronata</i> Forssk.	Annual	0.01	0.23	0.3
<i>Papaver armeniacum</i> L.	Annual	0	0	0.01
Annual forbs	Annual	1.46	2.30	3.32
Annual grasses	Annual	6.41	5.53	4.22
<i>Artemisia aucheri</i> Boiss.	Dwarf half-shrub	4.50	1.42	0.27
<i>Kochia prostrate</i> L.	Dwarf half-shrub	0.10	0	0.04
<i>Thymus kotschyanus</i> Boiss. & Hohen.	Dwarf half-shrub	0.15	2.77	3.56
<i>Astragalus microcephalus</i> Willd.	Legumes half-shrub	2.04	11.43	1.44
<i>Astragalus</i> sp.	Legumes half-shrub	0	0.09	0.02
<i>Onobrychis sativa</i> Lam.	Legumes half-shrub	0	0.01	0.02
<i>Achillea cuneatiloba</i> Boiss. & Buhse	Perennial forb	0.02	0	0
<i>Dianthus seidlitzia</i> Boiss.	Perennial forb	0.01	0	0
<i>Eryngium billardieri</i> Delar.	Perennial forb	0.87	0.53	0.63
<i>Euphorbia aucheri</i> Boiss.	Perennial forb	0.4	0.84	0.35
<i>Gundelia tournefortii</i> L.	Perennial forb	0	0.01	0.07
<i>Hypericum armenum</i> Jaub. & Spach.	Perennial forb	0	0	0.01
<i>Hypericum hirtellum</i> Boiss.	Perennial forb	0.03	0	0
<i>Onopordom acanthium</i> L.	Perennial forb	0.14	0	0.53

Appendix 1 Continued

<i>Phelomis olieveri</i> Benth.	Perennial forb	0	0	0.17
<i>Poterium sanguisorba</i> L.	Perennial forb	0	0	0.06
<i>Prangus uloptera</i> DC.	Perennial forb	21.79	0.91	0.66
<i>Scariola orientalis</i> Boiss.	Perennial forb	0.10	0.05	0.15
<i>Stachys inflata</i> Benth.	Perennial forb	1.01	2.04	1.65
<i>Stachys lavandulifolia</i> Vahl.	Perennial forb	0.11	0.02	0.01
<i>Verbascum stachydiforme</i> Boiss. & Buhse	Perennial forb	0	0.53	0
<i>Agropyron pectiniform</i> Roem. & Schult.	Perennial grass	0.20	0.26	0.10
<i>Agropyron trichophorum</i> (Link) K. Richt.	Perennial grass	0.02	0.09	0.69
<i>Bromus danthoniae</i> L.	Perennial grass	0	0	0.02
<i>Bromus tomentellus</i> Boiss.	Perennial grass	0.27	0.04	0.45
<i>Cynodon dactylon</i> (L.) Pers.	Perennial grass	0	0	0.24
<i>Festuca ovina</i> L.	Perennial grass	0	0.14	0.2
<i>Hordeum bulbosum</i> L.	Perennial grass	0	0.05	0.01
<i>Koeleria cristata</i> L.	Perennial grass	0	0	0.14
<i>Melica persica</i> Kunth.	Perennial grass	0.02	0	0
<i>Poa bubosa</i> L.	Perennial grass	5.59	0.61	0.02
<i>Stipa barbata</i> Desf.	Perennial grass	0.91	1.31	0
<i>Acanthophyllum microcephalum</i> Boiss.	Cushion half-shrub	0.59	6.46	0.65
<i>Amygdalus scoparia</i> L.	Shrub	0.09	1.62	0.28
<i>Pteropyrum aucheri</i> Jaubert & Spach	Shrub	0.07	0.04	23.21
<i>Rosa canina</i> L.	Shrub	0.01	0	0

تأثیر گونه های بوته ای غالب بر مقدار مواد آلی خاک در علفزارهای خشک

رضا عرفانزاده^{۱*}، بهنام بهرامی^۲، جواد معتمدی^۳، قاسمعلی دیانتی تیلکی^۱ و مهدی عابدی^۴

- ۱- دانشیار، گروه مرتعداری، دانشکده منابع طبیعی، دانشگاه تربیت مدرس، نور، ایران
- ۲- دانشجوی کارشناسی ارشد، گروه مرتعداری، دانشکده منابع طبیعی دانشگاه تربیت مدرس، نور، ایران
- ۳- استادیار، گروه مرتعداری، دانشکده منابع طبیعی و کشاورزی، دانشگاه ارومیه، ارومیه، ایران
- ۴- استادیار، گروه مرتعداری، دانشکده منابع طبیعی، دانشگاه تربیت مدرس، نور، ایران

تاریخ دریافت: ۲۳ دی ۱۳۹۴ / تاریخ پذیرش: ۱۳ فروردین ۱۳۹۵ / تاریخ چاپ: ۱۱ تیر ۱۳۹۵

چکیده مقدار نیتروژن کل، ماده آلی کل و مواد آلی ذره ای خاک در سه سایت علفمیتفاوت در گونه های بوته ای، شامل *Astragalus microcephalus* (بوته ای)، *Pteropyrum aucheri* (بوته ای) و *Prangus ulopteral* (غیربوته ای علفی) مقایسه شد. سایت ها در علفزارهای خشک شمال غربی ایران انتخاب شدند. بدین منظور، ۱۸ نمونه ی خاک در هر سایت به صورت تصادفی-سیستماتیک به وسیله مته از دو عمق ۰-۱۵ و ۱۵-۳۰ سانتی متر در طول ۶ ترانسکت در هر سایت در بهار ۱۳۹۰ برداشت شدند. نتایج نشان داد که بیشترین مقدار کربن کل در هر دو عمق (۹۹٪، ۹۸٪ درصد) و نیتروژن کل (۱۳٪، ۱۲٪ درصد) به ترتیب در سایت هایی مشاهده شد که گونه غالب آنها *P. Aucheri* و *A. microcephalus* بود. بیشترین مواد آلی ذره ای خاک برای کربن (۲۴٪ درصد) و برای نیتروژن (۰/۰۳ درصد) در سایت با غالبیت *A. microcephalus* به دست آمد. خاک در سایت با غالبیت *A. microcephalus* در مقایسه با دو سایت دیگر دارای سهم کمتری از ماکرو ذرات (۲۰/۴۶٪) و سهم بیش تری از میکرو ذرات (۲۸/۴۸٪) در لایه بالایی بود، در حالی که سهم میکرو و ماکرو ذرات در لایه پایینی خاک اختلاف معنی داری بین سه سایت مورد مطالعه نشان نداد. نوع گونه ای بوته ای در جوامع علفزار بایستی در مطالعات هجوم گونه های خشبی بر مواد آلی خاک اکوسیستم ها مورد توجه قرار گیرد.

کلمات کلیدی: علفزار، هجوم بوته، مواد آلی خاک، نوع پوشش گیاهی