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Comparison of aerial and underground carbon sequestration potential of *Stipa barbata* in Fasham Pastures, Iran

Maryam Saremi, Einollah Rouhi-Moghaddam*, Majid Sharifi-Rad

Department of Rangeland and Watershed, Faculty of Water and Soil, University of Zabol, Iran

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Abstract

Rangelands play an important role in the carbon cycle. Although their ability to absorb CO2 from the atmosphere could help offset human influence on climate change, there are many other ecological benefits associated with sequestering carbon on rangelands. Iran's rangelands have carbon sequestration capability by compatible species with the area. However, little information is available about the amount and distribution of carbon stocks in these rangelands. Fasham Ranges the infested city because of its proximity to Tehran, are very important in terms of carbon sequestration. This study aims was to compare above and underground carbon sequestration potential of a horse's mane (*Stipa barbata*) in Fasham pastures at two grazed and enclosured areas. In order to study the vegetation variables, the random – systematic sampling method was used. Then the plant biomass and organic carbon content in different plant organs was achieved. With the initial weight percent and organic carbon percent for above and underground biomass, conversion coefficient was calculated and by multiplying the initial biomass, carbon sequestration rate was achieved. The results showed that the average carbon sequestration in underground organs in both the grazed and enclousure is over than aboveground. There is a significant difference between the average carbon sequestration at underground organs of this species in grazed areas (12/79 kg per hectare) and enclosure (18/26 kg per hectare) (P <0.01).

***Corresponding Author:** Einollah Rouhi-Moghaddam ✉ rouhimoghaddam@yahoo.com.

Introduction

Land management practices offer opportunities to mitigate the rise in atmospheric CO_2 concentration through sequestration of carbon via storage in plant biomass and soil organic matter in a process termed terrestrial C sequestration (Izaurralde *et al.* 2001). Carbon sequestration also provides associated ecosystem cobenefits such as increased soil water holding capacity, better soil structure, improved soil quality and nutrient cycling, and reduced soil erosion (Derner and Schuman, 2007).

Rangelands due to the large size, have a high potential in carbon sequestration (Abdi, 2005). Pastures offer wide range of environmental, social and economic services (USDE, 2008). Generally ranges are included from about 47% of the Earth's lands. Although pastures biomass is negligible in comparison with forests, but due to the greater extent than forests are important from the perspective of carbon sequestration (Mesdaghi, 2001).

Soil C sequestration on rangelands is influenced by biome, climate (Conant *et al.*, 2001), management practices, and environmental factors (Jones and Donnelly, 2004). Even though C dynamics on rangelands involve complex interactions involving climate, soils, plant communities and management (Schuman *et al.*, 2001). Management of rangelands can aid in the mitigation of rising atmospheric carbon dioxide concentrations via carbon storage in biomass and soil organic matter, a process termed carbon sequestration (Derner and Schuman, 2007).

Grazing facilitates the physical breakdown, soil incorporation and rate of decomposition of residual plant material (Schuman *et al.*, 1999). Grazing intensity and frequency are thought to cause the primary effects on C storage across rangelands (Bruce *et al.*, 1999), although these effects are often inconsistent and difficult to predict (Reeder and Schuman, 2002). Grazing-induced changes in plant community composition are likely responsible for many of the changes in C sequestration observed with stocking rates (Derner and Schuman, 2007). Rathjen (2012), by reviewing of 34 researches that were done in grazed and enclosured areas in different parts of the world concluded that 60% of these researches showed carbon increases as a result of range enclosuring and some studies have reported that grazing has no effect on carbon sequestration.

Iranian ranges generally between 50 to 300 mm annual rainfall have the capability of carbon sequestration by species adapted to the area (some of which are also wood species are resistant to low rainfall and saline soils). However, little information on the amount and distribution of carbon stocks is existed in these pastures. Therefore, this study was performanced aimed to determine the *S. barata*'s aerial and underground organs carbon sequestration in Fasham rangelands.

Materials and methods

The study area

Fasham region is located in the North East of Tehran. The study area has 314.5 hectares surface which 159 he of it were enclosured in order to conservation of herbal and animal genetic reserves and other areas (155.5 ha) are explored on livestock grazing. Study area is located between longitudes 55 ° 35 to 58 ° 35 and longitude 29 ° 51 to 36 ° 51.

The total area is as the mountains or hills and a maximum altitude of 3500 m and a minimum height of 1800 meters above sea level. Absolute maximum and minimum recorded temperatures are respectively 39.8 and -11.4 degrees Celsius. The study area consists of Karadj formations of the red Miocene. Prevailing wind direction in the area is southwest and the annual average prevailing wind speed is 6.3 knots. Also, the annual strongest wind direction and speed, are averagely the west and 47 knots (Engineers adviser water land, 2007).

Sampling method

After preliminary identification and delimitation of the study area, in order to study the vegetation variables was used by random - systematic method. That each of the treatments (grazed and enclosured) two transect length of 100 meters (a transect perpendicular to the direction of the slope and a transect slope) along each transect, 10 plots of one square meter (based on plant distribution pattern) were established.

To determine canopy cover and dominant species, within each plot list of the plants and cover percent of plant species were determined.

For estimating above-ground biomass of plants including aboveground organs were used direct measurement method (cutting and weighing) (Milchunas and Laurenroth, 1993). Estimating underground biomass of this species was used from the root to shoot ratio. To this end, 10 individuals of this species were selected and were harvested by digging the soil to a depth of root penetration and root biomass. Then having a total weight of plant biomass (above + under ground biomass) underground biomass to biomass ratio was determined air. By applying this ratio in the weight of the aerial biomass, underground biomass weight was estimated in each two region (Froozeh *et al.*, 2008).

In order to determine the carbon conversion factor aerial and ground organic carbon, the combustion method was used (Bordbar, 2004; Abdi, 2005; Froozeh, 2006). Therefore, the plant samples that were oven-dried, were comminuted completely and were prepared 5 samples with 5 gr weight. Then the samples were located at the electric furnace temperature was 550° C for 5 hours. Samples (organic material or ash) after removal of the electric furnace and cooling, were weighted by the desiccator. Then according to equation (1) the amount of organic carbon in each plant organs individually were calculated. Finally, with the initial weight (5 g) and organic carbon content, based on equation (2), organic carbon conversion ratio was calculated for aerial and underground (Bordbar, 2004; Abdi, 2005).

Multiplied by the conversion ratio of organic carbon in fresh weight of aerial and ground based on equation (3), the total weight of sequestrated carbon was calculated.

Organic Carbon=0.5 Organic Matter (1)

(OC(gr) / sample weight = Conversion ratio of plant organ to organic carbon (2)

Conversion ratio of plant organ to organic carbon × initial fresh weight (gr/m^2) = carbon sequestration (gr/m^2)×10= carbon sequestration (kg/ha) (3)

Methods of data analysis

This study was conducted in a completely randomized block design. First, the data normality was investigated by the Kolmogorov - Smirnov test and homogeneity of variances were checked by Levene test. To compare plant biomass weight, conversion ratio and plant's carbon sequestration in two grazed and enclosured regions, the non-paired t-test was used. SPSS software for statistical computing and drawing charts in Excel 2010 was conducted.

Results

Weight of aerial and underground organs

As shown in Fig. 1 in the enclosured area, the weight of abovrground organ is higher than underground organ weight; however, underground organ weight is more the grazed area.

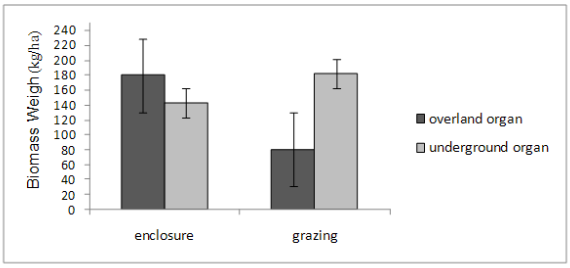

Fig. 1. Amount of overland and underground biomass in two enclosure and grazing region

Biomass conversion ratio to organic carbon

Comparing of the mean conversion ratio to carbon of this species by using of non-paired t-test confirm that between aerial and underground organs in the two regions there are not significantly different at 5% level. Also, the most of amount of this coefficient in both areas allocate to the underground organs (Table 1).

Table 1. Results of a non-paired t-test between the average carbon conversion ratio of the aerial and underground organs of *S.barbata* in the grazed pasture with similar biomass in the enclosured pasture.

Significant level	Free degree	average	treatment	index
ns0/347	2	0/035 0/022	grazing enclosure	Overland organ
ns0/082	2	0/1 0/089	grazing enclosure	Underground organ

ns: no significant difference

Carbon Sequestration

Carbon sequestration in underground organs of both the enclosured and grazed regions is over. Significant difference is observed between the two regions about of underground organs of *S.barbata* at 1% level (Table 2).

Table 2. Non-paired t test Shoot and underground carbon sequestration S.barbata species in grazed and enclosured areas treatments

Significant level	Free degree	standard deviation	average	treatment	index
ns0/359	2	1/18 0/65	2/835 3/96	grazing enclosure	Overland biomass
0/009 **	2	0/367 0/622	18/26 12/79	grazing enclosure	Underground biomass
ns0/092	2	1/548 1/272	21/095 16/75	grazing enclosure	Total of phytomass

ns: no significant difference

**: Statistically significant at the 1 percent level.

Discussion

Aerial organs of plant are the most sensitive part of an ecosystem that is most directly affected by grazing (Yousefian *et al.*, 2011). Although the results of some research suggest that the roots response to grazing is unclear (Frank and Karn, 2003), but it has been proven that the roots are playing a key role in the process of carbon sequestration in ecosystems, because they are the largest source of carbon entering the soil, especially in dry areas where the roots are included a significant prportion of total biomass (Sulzman, 2000).

In the enclosured pasture due to lack of grazing, Shoot weight increases. In the grazed pasture, harvests of shoot reduces its and roots are developed. Bunning (2009) suggest that under continuous grazing, grasses produce a strong root system. It also has been reported the underground biomass is increased under pressure of grazing (Luciuk *et al.*, 2000).

The results of the conversion coefficients shoot and underground is consistent with survey conducted by Froozeh (2006). Froozeh (2006) study the impact of grazing pasture on carbon sequestration potential of two species of halophilic *Halocnemum strobilaceum* and *Halostachys caspica*, (case study: rangeland Gomishan, Iran) and suggested that plants' organs conversion coefficient there are not significant differences between grazed and enclosured pastures. But Alizadeh *et al* (2010) investigated carbon sequestration ability of two species of *Artemisia sieberi* and *S.barbata* in three short-term and long-term enclosure and graze management treatments in the Saveh rangelands of Iran. In this research, aerial biomass conversion ratio to organic carbon for *S.barbata* had the highest amount in long term enclosure and the lowest amount in short term enclosure treatment. Underground organs conversion ratio to organic carbon for this species in the grazed area had the highest and lowest ranked at short enclosured management range. In the case of *A. sieberi*, aboveground conversion ratio to organic carbon was the highest in the long term enclosure and the lowest in the short term enclosure treatment. Also the largest underground organs conversion ratio in long-term enclosured and the lowest rate was observed in the grazed area. Between carbon conversion factors listed in three management there was significant difference at 1% level. Carbon sequestration in the studied species in the underground organs were more than aboveground organs due to the lower the moisture content and th higher wood percent.

Youssefian *et al* (2011) also investigated the potential of carbon sequestration in plain Artemisia species and found that between the organs of the plant, root plays the greatest role in carbon sequestration. Carbon sequestration of aerial organs in the enclosure area and carbon sequestration of underground organs in the grazed area was higher. This result is influenced by the weight of these organs. As mentioned, aboveground organs in enclosure and underground organs weight had the larger amounts.

Rathjen (2012) also focus on carbon sequestration in Ethiopia grassland and reached similar conclusions in this study. Grazing of livestock will have a huge impact on rangeland vegetation composition, primary production, the shoot to root ratio and nutrient cycling in pasture.

Studies have shown that light grazing of animals on pasture can lead to increased rates of carbon sequestration in relation to enclosured management and other management due to the increased efficiency of photosynthesis in plants (Rathjen, 2012). Man lives as an element of the ecosystem and for achievement of maximum benefit, creates change in it. The foundation of the ecosystem concept is that of its elements are linked together. People entering livestock in rangeland impacts on plants.

With correct management, plants and soil respond them self positively. In rangelands, the main tool for rangeland manager is the control of grazing pressure. Grazing pressure can be controlled by a resting of a part of the pasture in times of crisis and by regulating of operation season (Milchunas and Laurenroth, 1993).

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