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Effects of the height and geographical aspects on potential of soil carbon sequestration in Kermanshah, Iran

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Abstract

Main phenomenon of climate change that is harmful for human being, increased concentration of carbon dioxide in the atmosphere. Regarding to the potential of carbon storage in soil and plant tissues, this approach has a serious interest in recent decades. Due to the different climate zones in IRAN, share and amount of carbon sequestration in any of these areas need more contemplation. Therefore, the ability of soil carbon sequestration of mountain pastures in Kermanshah Province was studied in 3 height and 4 geographical aspects. Then, soil samples were taken from the areas that *Astragalus gossypinus and Astragalus parrowianus* grew at two depths of 0-30cm and 30-60cm. The amount of organic carbon, bulk density, electrical conductivity, pH, moisture content and soil texture in both depths of each soil profile were measured. Stepwise regression results also showed that texture parameters, bulk density and pH, respectively, were the most important factors affecting on soil organic carbon. Based on the results of data analysis using a completely randomized factorial design, significant differences were observed at 1% significance level between the two species and also in height between the classes and geographical aspect on soil carbon sequestration rates. Comparison of results based on SNK tests also indicates that, biggest amount of carbon sequestration taking place in the maximum height in the geographic north aspect. Also according to the results can be stated that capability of soil carbon sequestration in *Astragalus parrowianus is more than Astragalus gossypinus.*

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Introduction

Global Warming is the phenomenon of a gradual increase in average earth temperature and climate change which are linked to global warming. Frequent occurrence of droughts and glaciers melting over the past century, are examples of Global Warming. This phenomenon is directly associated with increase of greenhouse gases accumulation in the atmosphere. One of the most important greenhouse gases, carbon dioxide, the dramatic increase in recent years and it has adverse effects on human life and the environment. One of well known approaches to control this phenomenon is atmospheric carbon trapping method, which is divided into non-biological and biological methods (Kerr, 2007). Biological method includes absorption of atmospheric carbon dioxide by vegetation and soil, and transforming it into biomass, and then conversion of biomass to organic carbon or humus (Nadi *et al*, 2012). According to William (2002), changes in atmospheric carbon dioxide into organic compounds by plant biomass and soils contain this plant biomass, is one of the easiest and cheapest possible solution to reduce atmospheric CO2. These effects threaten sustainable development in many countries and have led to a sharp increase in worldwide studies (Stern, 2007). Approximately 85 million hectares out of 164 million hectares are pasture ecosystems in Iran (Forest, Rangeland and Watershed Organization, 2006).Pasture ecosystems includes various forms of vegetation such as shrubs, grasses and forbs. Plant vegetation of shrub lands has significant root biomass, which sometimes exceeds 80% of the total weight of plant biomass. This vegetation is durable and reliable. So it seems to has the key role in atmosphere carbon sequestration and transfer it to underlay soil (Mahdavi *et al*., 2012). Gradual increase of carbon dioxide and global warming is a global issue and is relevant to all countries. Given the breadth of the country as well as pasture lands, research on Carbon Sequestration in pasture ecosystems appear to be necessary. Many unknowns and potential problems related to the ability of different pasture species on Carbon

Sequestration in different climate parts of IRAN are existed. Extensive researches are needed to resolve these issues. This research also examines the carbon sequestration potential of soils and the dominant plant species influenced by physiographic factors in mountain pastures, in Kermanshah province, Iran.

Abdi (2005), argues that shrub species not only in terms of soil conservation, biodiversity, and high resistance to environmental stresses such as drought reserves inheritance and cold, can have many benefits, but also they have important impact on carbon sequestration. Vegetation not only has a wide impact on atmospheric carbon dioxide absorption, but also, providing plant debris, impacts on soil carbon storage. Vramesh (2009) research results, indicates the relation between soil organic carbon sequestration, and plant cover, plant species, the amount of litter, type of land use and management. So, if vegetation type is properly selected in an area, soil organic carbon value will increase in long-term.Snorrason *et al* (2002) did a research on rangeland soil in a period of 33 years, and stated that soil carbon sequestration rate is 157 tons per acre. In recent years, consideration to carbon sequestration as an influential factor on soil organic matter has increased. Also, soil carbon sequestration, as a good way to reduce atmospheric CO_2 concentration, is more discussed in the scientific and political communities of the world. Soils of the world are the third main reserve of carbon (organic and inorganic). These contain about 4 times as much carbon in biomass, and 3.3 times as much carbon in the atmosphere (Lal, 2004). Chen *et al* (2006) said that, topographic factors depending on the shape and complexity of terrain, affects on movement and transfer of soil moisture; As a result, they significantly affect the capabilities and productivity of ecosystems.*A. gossypinus and A. Parrowianus* species is abundant and widely grown in Zagrus mountain ranges, especially in Kermanshah province. Therefore, considering the amount of growth and the practical characteristics of such species in terms of the amount of soil carbon

sequestration, it seems highly essential to carry out the soil carbon sequestration in the Zagrusareas in Kermanshah province. For that reason, the present study investigated the effect of height and geography aspect on the degree of potential soil carbon sequestration.

Materials and methods

Geographical location of study area

The study area with an area of approximately 3200 acres is located in geographic coordinates 46º 22' 42" to 46 º 27' 55" east longitudes, and 34 º 42' 11" to 34 º 48' 4" north latitude, in Kermanshah province, IRAN. The minimum height of area is 1071 meters and maximum height is 2083 meters above sea level. The regional climate based on a modified Domarton method, is cold and wet.

Fig. 1. Study area geographical coordinates.

Methodology

After determining the scope of the study area based on 1:25000 topographic maps and geographical field, layer information based on the slope of the four main directions (E, W, S, N) and Hypsometry in 3 height floors (1100m to 1500m, 1500m to 1900m, and more than 1900m high) and homogeneous units based on them were prepared. Then, reagent regions (a small area that represents a homogeneous region), were elected in each homogeneous unit. Then, in each reagent region, three 50-meters linear transects, parallel to each other, from the top of the range to the bottom with a 45 degree angle to the direction were made. In a distance of 10 meters along transects, 1-square meter plots were dropped. Appropriate number of sampling plots is obtained

using statistical methods to determine sample size based on equation (1) (Bihamta *et al* (2010).

Equation (1):

$$N = \frac{t^2 s^2}{p^2 x^2 (1 + (\frac{2}{n}))}$$

N= minimum number of required samples

t= is obtained from t-Student Table with the desired level

s²= Variance of Initial Sample

n= Number of Initial Sample

p= error limits

x= mean of Initial Samples

Percentage and density indexes of vegetation cover were measured to determine the dominant species in each plot. Two species of Astragalus Gossypinus and Astragalus Parrowianus that had the highest cover percentage and presence were selected for review. Soil profiles in both 0-30cm and 30-60cm depth were made and sampling from both depths was conducted in all homogeneous units. Samples were transported to the laboratory, and organic carbon parameters using Walky-block method. Bulk density was calculated using the sintering method. Soil texture was determined using hydrometer method. Soil electrical conductivity was measured using an EC meter. Soil pH was measured using a pH meter (Jafari haghighi, 2003). In order to determine carbon sequestration in the scale of grams per square meter, equation (2) was used (Zahedi, 2002):

Equation (2): $Cc = 100 \times C (\%) \times Bd \times e$

Cc= amount of carbon sequestration in one square meter surface

C= percentage of the carbon density at certain depth of soil

Bd= soil bulk density in grams per cubic centimeter

e= soil depth thickness in centimeter

In the final stage of research, in order to evaluate and compare the influence of physiographic factors and existence of *Astragalus Gossypinus* and *Astragalus Parrowianus* species on soil carbon sequestration potential, statistical analysis using a variance analysis with factorial designed format with the completely randomized basic design were done. SPSS (version 18) and Excel software were used in

this manner. It is worth noting that to compare the means, SNK test was performed.

Results

Results of variance analysis of factorial design are given in the Table 1. Regarding to Table 1, between two studied species and also between height levels

and directions, there is significant difference in all indicators at 1% level. Also, the results suggest the existence of significant interaction on indicators at the confidence level of 95 percent. Mean comparison results based on SNK test at 5% significance level are presented in Tables 2 and 3.

Table 1. Results of F statistic of indicators based on analysis of variance test.

change resources	degrees of freedom	density per hectare	cover percentage	carbon sequestration in first depth soil	carbon sequestration in second depth soil
species	1	7.13**	7.57**	9.41**	12.16**
height	2	12.16**	11.33**	13.01**	13.82**
direction	3	5.23**	4.99**	6.13**	9.44**
species * height	2	10.53**	4.16**	6.76**	8.22**
species * direction	3	6.24**	7.26**	10.13**	12.23**
direction * height	6	4.77**	11.23**	16.71**	16.71**
species * direction * height	6	2.92*	2.53*	1.99*	2.32*

* and ** indicate significance different at the 5 percent and 1 percent significance level.

Table 2. Comparison of indicators in different height classes.

height levels	carbon sequestration in first depth soil		carbon sequestration in second depth soil		vegetation per hectare	
	mean	group	mean	group	mean	group
1: 1100-1500	294.5	C	466.7	C	19.2	B
2: 1500-1900	344.3	B	525.6	B	25.5	A
3: 1900-2100	354.70	A	586.50	A	26.8	A

Table 3. Comparison of studied indicators in different geographical directions.

direction	carbon sequestration in first depth soil		carbon sequestration in second depth soil		vegetation per hectare	
	mean	group	mean	group	mean	group
North	599.60	A	407.8	A	29.2	A
South	405.52	D	287.4	D	18.1	C
East	552.60	B	310.6	B	24.3	B
West	499.19	C	300.6	C	20.6	C

Table 4. The difference between the indicators averages of two species of *Astragalus parrowianus* and *Astragalus gossypinus*.

species	carbon sequestration in first depth soil	carbon sequestration in second depth soil	vegetation per hectare %	density per hectare n/m²
Astragalus gossypinus	560.12	450.57	14	1
Astragalus parrowianus	489.50	399.53	26	2.5

According to the Table 2 we find out that from lowest height upward, the amount of carbon sequestration increases. The mentioned trend is true for other plant indicators. Going from lower height level to

higher levels, amount of vegetation significantly increases.

Results in Table 3 express the fact that biggest indicators in amount are on the North direction, and

the smallest ones are on the South direction. Both East and West, in case of studied indicators, had a moderate amount. The difference between the indicators averages of two species of Astragalus Parrowianus and Astragalus Gossypinus are presented in Table 4.

The results of Table 4 indicate that carbon sequestration potential of Astragalus Parrowianus is more than Astragalus Gossypinus in both soil depths. Finally, results of stepwise regression of soil organic carbon in relation to soil factors are presented in the Table 5.

Table 5. Stepwise regression analysis of soil organic carbon (follower variable) with soil factors.

coefficient	equations
57.3	$Y = 22.4 + 0.72X_1$
71.6	$Y = 7.99 + 0.79X_1 + 1.2X_2$
80.7	$Y = 6.4 + 0.35X_1 + 1.3X_2 - 0.57X_3$

Y= carbon weight   X1 = clay   X2 = bulk density   X3 = pH

Stepwise regression analysis of soil organic carbon and soil factors shows that the amount of clay is one of the most important components that affects on soil organic carbon. Soil bulk density is next in importance (14.3%). Acidity is the next component that influences on density of soil organic carbon (9.1%).

Discussion and Conclusion

The results indicate that geographical height and direction significantly affect on soil carbon sequestration potential of species. The most amount of soil carbon sequestration in both studied species belongs to highest elevation of the floor and the northern latitudes.

This result is consistent with Azarnivand *et al* (2003) who stated altitude is one of the most important parameters that influence the climate in regional parameters such as temperature and precipitation, can have an important impact on soil vegetation properties. It appears that increase carbon

sequestration potential at the highest floor due to the high vegetation index, vegetation density, cover percentage and biomass production that is because of geographical particular situation, being impassable and reducing livestock grazing in this height level.

Due to human activity, ease access of livestock to the low height levels, high utilization of the pastures in this level, and high soil erosion, soil carbon sequestration rate is low in this level. This subject is consistent to Brown *et al* (2004) who expressed that topography has a significant role in changing the micro climate, through influence on temperature, rainfall and light absorption.

The amount of soil organic carbon in both studied species in depth 0-30cm was more than 30-60, that is same as findings of Schuman (2002) and Varamesh (2011). This could be due to excessive accumulation of plant debris in the soil. Results show (Table 5) that the amount of clay and bulk density, are the most important components affecting soil organic carbon. Also Powers *et al* (2002) research results showed that organic carbon concentrations are associated with amount of clay in soil.

Kolahchy (2005) a survey conducted in enclosure pastures in Hamadan province concluded that, soil organic carbon is highly correlated with soil bulk density, plant production rate, the percentage of vegetation and litter. Abagale *et al*. (2012) and Wilcox (2002) concluded that some of the affective factors on soil carbon sequestration potential of forest ecosystems are various soil factors and region topography. Singh (2003) believes that the amount of soil organic matter and consequently the amount of sequestrated soil carbon per area unit depends on a variety of factors including soil bulk density.

Another important result of this study was comparing the carbon sequestration potential between the two studied species, Astragalus Parrowianus and Astragalus Gossypinus.

Determined carbon sequestration potential of Astragalus Parrowianus is more than Astragalus Gossypinus. It seems that this ability is because of more amount of aerial and root biomass, and cover vegetation in Astragalus Parrowianus in compare with Astragalus Gossypinus. This ability leads to trap and sequestrate more organic carbon. At the end, it is suggested that regarding to the importance of pasture species and rangeland ecosystem soils on carbon sequestration, researchers should make more efforts to further understanding of this ecosystem, in order to increase the amount of carbon sequestration and reduction of atmospheric carbon influence.

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