Contents available at ISC and SID
Journal homepage: www.rangeland.ir

Research and Full Length Article:

Comparing Soil and Phytomass Carbon Sequestration in Two Land Uses: Rangeland and Cropland (Case Study: Mahallat, Galcheshmeh Region, Iran)

Farhad Derakhshan[A], Nourollah Abdi[B*], Hamid Toranjzar[C], Abbas Ahmadi[C]
[A] Ph.D. Student of Range Engineering and Science, Department of Range and watershed Management, Arak Branch, Islamic Azad University, Arak, Iran
[B] Associate Professor, Department of Range and watershed Management, Arak Branch, Islamic Azad University, Arak, Iran. *(Corresponding author), Email: n-abdi@iau-arak.ac.ir
[C] Assistant Professor, Department of Range and watershed Management, Arak Branch, Islamic Azad University, Arak, Iran
Received on: 27/03/2020
Accepted on: 01/05/2021
DOI: 10.30495/RS.2022.681397
DOR: 20.1001.1.20089996.2021.12.1.2.7

Abstract. Rangelands rehabilitation have a high priority for improving the environment and mitigating climate changes in comparison to natural rangelands. This study was conducted to compare carbon sequestration in soil and phytomass between land uses of rangeland and irrigated agricultural farms in Mahallat, Markazi province, Iran. The soil was sampled by setting profiles (17 Land uses) in two depths of 0-15 cm and 15-30 cm. In the both land uses, three 50 m transects were established with four 2×2m plots sampled in each transect with random distances. Soil samples were taken from center of each transect. The contents of aboveground and underground biomass carbon, litter carbon and soil organic carbon were determined (in summer 2017). Percentage of organic carbon of plants and soil samples was measured in the laboratory. Soil bulk density, texture, acidity and electrical conductivity were determined. The carbon sequestration in phytomass and soil between rangeland and cropland was compared using independent t-test. Result showed significant effect of carbon sequestration in phytomass, Litter ($P<0.01$) and soil (not Significant) between rangeland and cropland land uses. Total carbon sequestration in rangeland ecosystem (59471 kg/ha) was higher than carbon sequestration in cropland (53314 kg/ha). Therefore, despite the lack of irrigation and fertilizer inputs, the amount of carbon sequestration in rangeland was higher than the cropland in the region.

Key words: Soil organic carbon, Soil fertility, Range rehabilitation, Markazi province

Introduction

The global rise in concentration of atmospheric carbon dioxide along with other greenhouse gases are related to consumption of fossil fuels, cement production and land use changes. In agriculture, burning of phytomass, drainage of wetlands, application of chemical fertilizers and tillage are amongst the most important factors in the increase of greenhouse gases (Lal, 2002). Improvement of rangeland management could have a considerable role in the decrease of carbon dioxide emission (Morgan *et al.*, 2010). Information on soil aggregation, soil organic carbon (SOC) stabilization and use in determination of rangeland capacity helps to long-term sequestration of carbon in the soil (Ahmadi *et al.*, 2013; Ramesh *et al.*, 2019). Soil type and properties, vegetation, climate and weather conditions as well as management practices all have a considerable effect on the carbon fluxes and balances of agroecosystems (Heimsch *et al.*, 2020). Decrease in atmospheric CO_2 and carbon sequestration in soil and vegetation can decrease the rate of climate changes and global warming. There are global efforts to confront the climate changes, including application of clean energies, carbon sequestration in agricultural ecosystems, rehabilitation of deforested forests and afforestation in arid and semi-arid regions and agroforestry (Hasangholi-Pur *et al.*, 2019; Bai *et al.*, 2020). Carbon sequestration acts as a process in which atmospheric CO_2 is stored in vegetation tissues as carbohydrates. Then, some part of it changes in litter carbon and organic carbon and stores in the soil (Abdi, 2006).

Rangelands are the largest natural ecosystem in Iran that covers about 54% areas of the country (Ariapour *et al.*, 2016) and rangeland management helps carbon sequestration by storing carbon in biomass and organic matters of soil (Derner *et al.*, 2007). Soils of the world's agroecosystems (croplands, grazing lands, rangelands) are depleted from their soil organic carbon (SOC) pool by 25–75%, depending an annual average on climate, soil type, and historic management. The magnitude of loss may be 10 to 50 tons C/ha. Soils with severe depletion of their SOC pool have low agronomic yield and low use efficiency of added input. (Lal, 2011).

Soil organic carbon (SOC) is one part in much larger global carbon cycle that involves the cycling of carbon through the soil, vegetation, ocean and the atmosphere (Lefèvre *et al.*, 2017). The amount of SOC in the topsoil of rangelands is higher than that of farms and therefore, there are higher amounts of carbon sequestration in rangelands than farms (Parsamanesh *et al.*, 2015). Organic matter in the soil is an important source of nutrition for plants and can increase the integrity of soil, decrease its erosion and increase the capacity of Cation exchange and water retention (Conant and Paustian, 2002). Total carbon sequestration in *Astragalus* rangelands in Shazand, Markazi province was 32950 (Kg/ha). About 87% of total carbon sequestration was stored as organic carbon in the soil. Distribution of organic carbon indicated that carbon storage in aerial biomass of the plant was higher than roots (Abdi *et al.*, 2008). Therefore, reclamation of rangelands degraded by overgrazing may potentially result in atmospheric carbon sequestration (Conant and Paustian, 2002). The results of a study in the area of Hossein Abad educational-research station in the west of Shiraz, Fars province, Iran showed that concentration of carbon in soil in substratum of Amygdalus (*Amygdalus scoparia* Spach) was higher than concentration of carbon in soil located in substratum of grape plants (*Vitis vinifera L.*), and biomasses of grape plants and Amygdalus were able to store an annual average of 30.55 and 5.88 (Kg/ha) of total organic carbon, respectively. Potential of carbon sequestration in the soil of grape plants and Amygdalus were estimated 271400 and 354100 (Kg/ha) in duration of 33 and 20 years, respectively (Ghanbarian *et al.*, 2015).

Rangeland ecosystems have a high potential for carbon sequestration. That is due to their vast area which encompasses half of the terrestrial lands of the world and their carbon storage is 10% of total stored carbon in terrestrial biomass and 30% of organic carbon of the soil. In global scale, rangelands sequestrate 500 billion tons of carbon annually. On the other hand, arid lands cover 45% of the terrestrial lands and despite the low content of organic carbon in their soil, these areas contain 16% of total storage of carbon in the soil throughout the world. The input of organic carbon to arid ecosystems is low. However, these areas may have high potential in sequestration and storage of carbon. This demands to increase the input of organic carbon into soil and decrease the decomposition and waste of carbon content in the soil with proper management (Badehian and Mansouri, 2017). This research was aimed to compare the amount of carbon sequestration between two land uses of agriculture and rangeland in an international project of carbon sequestration in Mahallat, Markazi province, Iran.

Material and Methods

Study area

The Gal-Cheshmeh rangeland in the Markazi Province, Iran include an area about 31000 ha and is located in 30 km Southeast of Mahallat (50º 19´ 56˝ to 50º 39´ 26˝ E and 33º 38´ 47˝ to 33º 48´ 23˝ N) in central Iran (Fig. 1). This area is selected for international project of carbon sequestration. The elevation ranges from 1550 m to 2300 m above sea level. This project was conducted to enhance local people's role in the control of desertification, especially in southern parts of Markazi province, Iran. This place was chosen for the implementation of project of carbon sequestration due to such problems as erosion, poverty and migration because of desertification. The area has a great potential of water and soil resources and local people participated and full support of decision makers from the project of carbon sequestration. Gal-Cheshmeh with an area encompass Yeke-Chah, Jamal-Abad, Judan, Chehel Roz, Jordijan, Tutak, Erghadeh and Gal-Cheshmeh with population of 1500 individuals. There are 13517 sheep (*Farahani*) and goats (*Najedi and Lori*) and 114 cows (*Golpayghani and Holstein*) races. The minimum elevation above sea level is 1550 m in Arghadeh region and the highest elevation is 2300 m in Gal-Cheshmeh. There is a plantation of seedlings of *Amygdalus scoparia, Rosa damascena* with an area of 15 ha. Moreover, there are a germplasm of 20000 seedlings of *Atriplex canescens, Zygophyllum atriplicoides* in the area that were planted by participation of local people. These are among the most important actions performed in the international project of carbon sequestration in this area.

Average characteristics of vegetation, litter and soil of aforementioned rangelands were considered as rangeland work unit. To evaluate the carbon sequestration in agricultural ecosystems, three farms in the vicinity of Chehel-Raz and Yekeh-Chah villages were chosen. During the sampling period (summer 2017), these farms were under rotation and cultivation of fallow *barley* and *Rosa damascena* (for 3 and 6 years old). Average characteristics of the studied farms were considered as agricultural work unit.

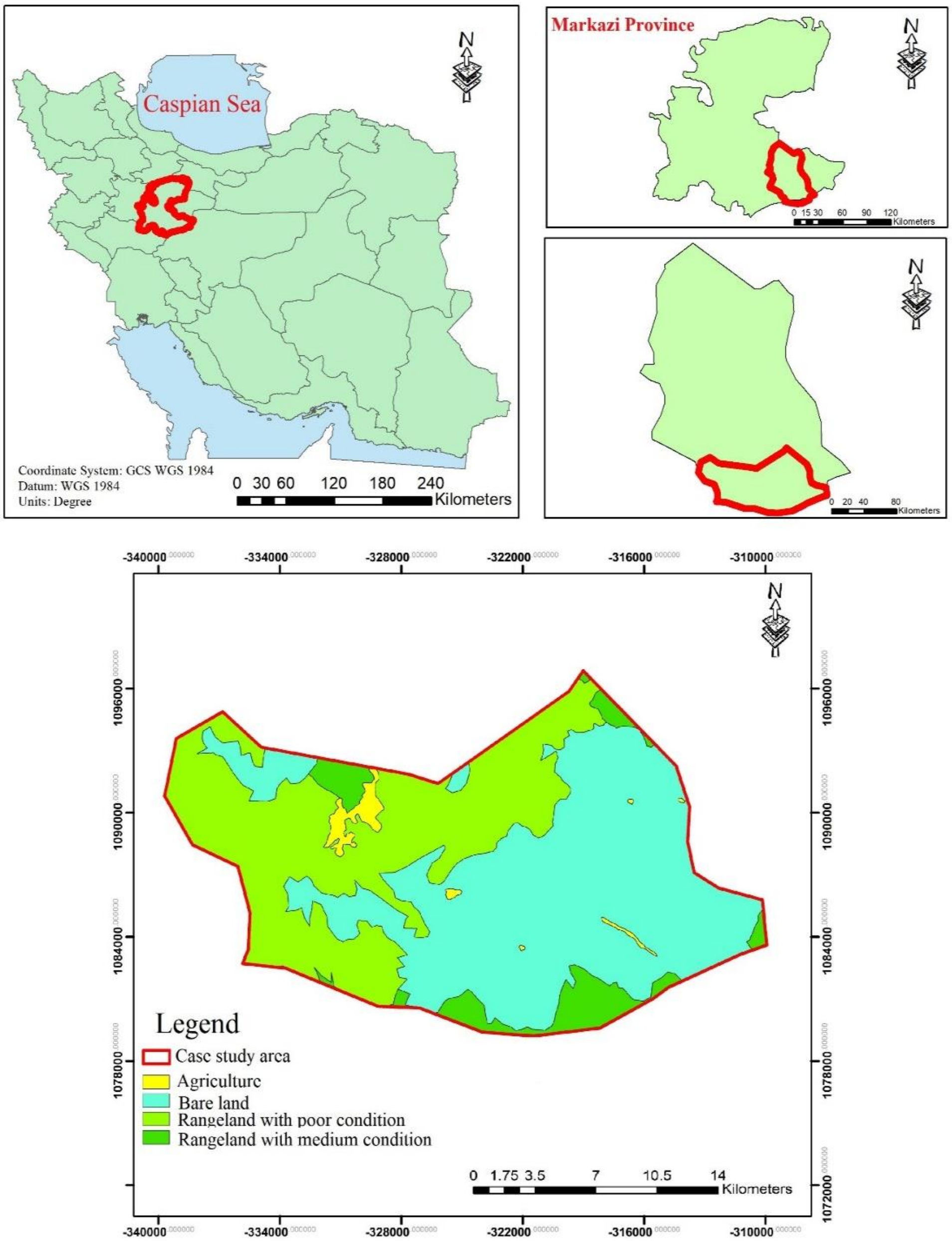

Fig. 1. Location of the study area

Research Methods

After primary identification and delineation of the study area, work maps were produced. To investigate the amount of carbon sequestration in rangeland and croplands in Mahalat, seven rangelands around villages of Chehel-Raz, Yekeh-Chah, Jamal-Abad and Gal-Cheshmeh with vegetation types of *Artemisia sieberi - Scariola orientalis - Astragalus gossypinus*, *Artemisia sieberi - Acantholimon bracteatum*, *Artemisia sieberi - Euphorbia decipiens* were selected. These rangelands were under the continuous or heavy grazing, moderate grazing, low grazing, and restoration with three species of *Atriplex canescens*, *Zygophyllum atriplicoides* and *Amygdalus scoparia*, respectively.

In each vegetation type of rangeland or in each farm, three transects with 50 m length were established. In each transect, four plots of 2×2 m with random distance were sampled. In each plot, species composition and vegetation cover percent was identified. In order to measure the aerial biomass, the aboveground biomass cut and weighed to calculate total aerial biomass for each plot. To measure the root biomass of dominant plants in rangelands (*Artimisia sieberi, Astragalus gossypinus,* grasses, *Atriplex canescens, Zygophyllum atriplicoides Amygdalus scoparia*) and crops in farms (*Hordeum vulgaris* and *Rosa damascena*), for each dominant plant, three samples with small, medium and large sizes were taken by digging the soil around the roots and extraction of all of the roots from the soil.

Moreover, existing evidence in the area (such as roots of present species in trenches located in the plan area) was used to increase the precision of estimation of the ratio of root biomass to aerial biomass. To determine percentage of aerial and root dry biomass, samples of dominant vegetation were cut and weighed and put in paper bags.

In the laboratory, samples were put inside the oven (with temperature of 75°C for 24 hours) to dry and the dried weight was measured for each sample.

To determine the amount of litter in each plot, based on available litter, all or at least one-fourth of the litters in each plot was collected and weighed. In measuring root biomass, all soils were sampled to a minimum depth of 30 cm, core sampling was done to determine root biomass in the 0-30cm soil depth, and included consideration of precision needs, the availability of data on root distributions for the species being inventoried, soil depth, texture and stoniness (MacDicken, 1997). The sampling method of vegetation cover and soil (in two 0-15cm, 15-30cm) was systematically randomized and samples were collected from 15 every 2m^2 plots along 3 transects (50m), totally, 102 plots from work units of rangeland and agriculture were evaluated.

In laboratory, soil texture was studied by applying Bouyoucos Densimeter method, which is based on the theory of changes in special weight (weight per unit of volume) of mixture of soil and water during sedimentation (Zarinkafsh, 1993). Bulk density of soil was determined by soil mass method (g cm^{-3}). Soil acidity was measured using Potentiometric method with application of electronic pH meter. Electrical conductivity (EC) of soil was measured by electronic EC meter. Percentage of soil organic carbon (SOC) was measured by Walkley-Black method. To calculate the carbon sequestration, (kg/ha) the following equation was used (Badehian *et al.*, 2015):

$$Cs = 1000 \times \%OC \times Bd \times E \quad \text{Equation 1}$$

Where: Cs: organic carbon (kg m^{-2}),
Bd: Soil bulk density (g cm^{-3}),
OC: percentage of organic carbon,
E: depth of soil sampling (cm)

To determine the carbon exchange coefficient in litter and phytomass samples, all of the samples obtained from stem, branch, root and litter were put inside the oven with temperature of 75°C for 24 hours. To measure the percentage of organic carbon in samples, the method of burning using electric furnace was applied. To do so, samples were dried, ground and three subsamples with 3 g weight were taken. Samples were weighed and put inside the furnace for 3-4 hours at temperature of 550°C. Burned samples were dried in a desiccator and then weighed. Weight of ash, primary weight and ratio of organic carbon to organic matter were input in equation (Hasangholi-Pur *et al.*, 2018) to calculate the amount of organic carbon in each organism of dominant plant species and litter, separately (MacDicken 1997; Abdi, 2005).

$$\mathrm{OC} = \frac{1}{2}\mathrm{OM} \quad \text{Equation 2}$$

Where:
OC=Organic carbon,
OM=Organic matter,

To determine the indices of carbon sequestration in rangeland and cropland in the study area and organic carbon storage in the soil, the storage of carbon in aerial phytomass, roots and litters and total sequestrated carbon in each plot were measured.

Data analysis

In order to perform the statistical analyses, the normality of the data was tested by applying Kolmogorov-Smirnov test. The homogeneity of variances was tested by Leven test. To compare total carbon sequestration and partial sequestration (sequestration in soil, biomass and litter) between rangeland and cropland, T-test was applied. All the statistical analyses were performed by SPSS (V. 24.0).

Results

The investigation of soil characteristics in the study area (Table 1) indicated that for the soil texture there was no difference between two lands uses (Rangeland and Agriculture) and both were sandy-loam type. The percentage of saturated humidity in agriculture land use increased from the topsoil to the lower layers of the soil. However, in rangeland land use, percentage of saturated humidity was higher in the topsoil. Bulk density was not significantly different between two land uses. Amount of lime and soil acidity was slightly higher in the agricultural land use. The EC was substantially higher in agricultural land use in comparison with rangeland land use.

Results of mean comparisons of soil carbon sequestration between rangeland and agriculture land uses are presented in Table 2. These results indicated that carbon sequestration was not significantly different between two studied depths in two land uses of rangeland and agriculture. Moreover, maximum and minimum amount of carbon sequestration occurred in the second depth of rangeland land use with 30746 kg/ha and the second depth of agriculture land use with 21703 kg/ha, respectively.

Table 1. Physical and chemical characteristics of soil in the study area

Treatment	Soil depth (cm)	EC (ds m^{-1})	pH	$CaCO_3$ (%)	Bulk density (g cm^{-3})	Soil moisture (%)	Soil texture
Cropland	0-15	2772	7.63	46.60	1.87	24.93	Sandy loam
	15-30	1956.60	7.61	47.85	1.88	26.24	
Rangeland	0-15	580.70	7.52	44.80	1.82	22.50	Sandy loam
	15-30	443.20	7.53	44.53	1.78	21.70	

Table 2. Comparison of carbon sequestration in soil in two depths in rangeland and cropland by applying independent T-test

Soil depth(cm)	Treatment	Soil carbon (kg/ha)	SE	DF	t	Sig.
Topsoil 0-15	Cropland	25767.00	242.44	43	-0.556	0.82^{ns}
	Rangeland	28276.80	207.53			
Subsoil 15-30	Cropland	21703.50	186.79	43	-2.041	0.43^{ns}
	Rangeland	30746.10	228.07			

^{ns} = Not significant SE=Standard error

Mean SOC between rangeland and cropland land uses is presented in Table 3. These results indicated that SOC was not significantly different between 0-30 cm depths in two land uses of rangeland and cropland. Moreover, maximum and minimum amounts of SOC occurred in rangeland land use with value 59022 kg/ha and of cropland land use with value 47470 kg/ha, respectively.

Table 3. Comparison of Organic Soil Carbon in soil rangeland and cropland land uses using independent T-test

Soil depth (cm)	Treatment	Soil carbon (kg/ha)	SE	d.f.	t	Sig.
0-30	Cropland	47470.50	408.58	43	-1.359	0.811^{ns}
	Rangeland	59022.90	228.07			

^{ns} = Not significant

Mean carbon sequestration in aerial biomass, litter and underground parts of plants were significantly different between rangeland and cropland land uses. Amount of carbon sequestration in aerial and underground biomass and litter was higher in cropland than rangeland (Table 4).

Results of mean carbon sequestration comparison between cropland and rangeland are presented in Table 5. Results showed that despite the fact that carbon sequestration in phytomass and litter in cropland were higher than those of rangeland, total carbon sequestration was not significantly different between cropland and rangeland. Amounts of carbon sequestration in rangeland and cropland were 59471 and 53314 kg/ha, respectively.

Estimation of carbon sequestration in rangeland and cropland (Fig. 2), showed that total carbon sequestration in cropland was determined to carbon sequestrations in litter (1.82%), phytomass (9.14%), subsoil (48.33%) and topsoil (40.71%). However, in rangeland, total carbon sequestration was determined as 0.2% in litter 0.56% in phytomass, 45.55 % in topsoil and 51.70% in the subsoil. Therefore, phytomass in rangeland had a less important role in carbon sequestration than phytomass in cropland (Fig. 2).

Table 4. Comparison of carbon sequestration in aerial and underground phytomass and litter between rangeland and cropland land use using independent T-test

Phytomass	Treatment	Carbon (kg/ha)	SE	d.f.	t	Sig
Aerial	Cropland	1592.10	30.03	43	3.757	0.00**
	Rangeland	260.10	2.43			
Underground	Cropland	3283.50	80.88	43	3.387	0.00**
	Rangeland	70.20	0.78			
Total (Aerial+ Underground)	Cropland	4875.60	110.36	43	3.509	0.00**
	Rangeland	330.30	3.06			
Litter	Cropland	968.50	21.86	43	3.314	0.00**
	Rangeland	118.40	0.61			

**= Means of square are significant at 1% probability levels

Table 5. Comparison of carbon sequestration in phytomass and soil between rangeland and cropland land uses using independent T-test.

Ecosystem component	Treatment	Carbon (kg/ha)	SE	d.f.	t	Sig
Soil	Cropland	47470.50	408.58	43	-1.359	0.81ns
	Rangeland	59022.90	416.01			
Phytomass	Cropland	4875.60	110.36	43	3.509	0.00**
	Rangeland	330.30	3.06			
Litter	Cropland	968.50	21.86	43	3.314	0.00**
	Rangeland	118.40	0.61			
Total	Cropland	53314.60	514.86	43	-0.663	0.53ns
	Rangeland	59471.70	417.59			

**, ns = Means of square are significant at 1% probability levels and non-significant

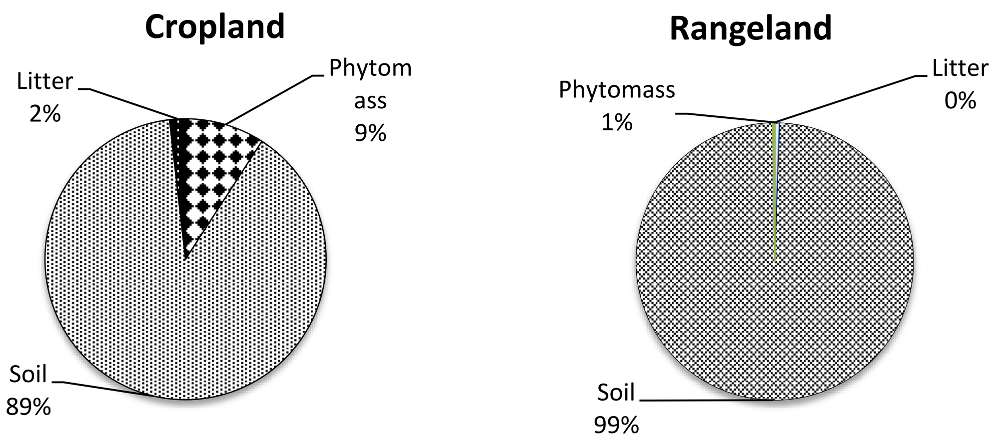

Fig. 2. Total carbon sequestration in soil, Phytomass and litter in cropland and rangeland land uses

Discussion

Lal (2002) reported that the importance of carbon sequestration in the soil is described as a win-win situation. That is because of the removal of carbon dioxide from the atmosphere and benefits from increase of carbon in the soil such as increase in the cation exchange capacity, soil productivity, water retention capacity and decrease in soil erosion. Batjes (2019) showed that reported potentials for sequestration of carbon in soils of agricultural lands are overly optimistic because they assume that all degraded cropland and grassland can be subjected to best management practices. The results showed that the carbon sequestration of phytomass (both above ground and underground) in rangeland was significantly lower than cropland. In contrast, the carbon sequestration of soil in rangeland was significantly higher than cropland (Table 5). The lowest amount of carbon was observed in cultivation of barley. According to (Chambers *et al.*, 2016) in USA, (Nosetto *et al.*, 2006) in the northwestern Patagonia of Argentina and (Gebregergs *et al.*, 2019) in Ethiopia, concluded that organic carbon is reduced by changing the use of rangeland to agriculture land uses.

The results showed that that total carbon sequestration in rangeland (59471 kg/ha) was higher than carbon sequestration in cropland (53314 kg/ha) (Table 5). In Iran, in some studies in the semi-arid rangelands such as: Sisab Bojnourd, Khorasan province (Naghipour *et al.*, 2009), Maranjab desert region of Aran-o-Bidgol (Ahmadi *et al.*, 2015), Malmir rangeland of Shazand region, Markazi Province (Abdi *et al.*, 2008), Gorgou Summer rangelands, Kohgiluyeh and Boyer-Ahmad Province (Farazmand *et al.*, 2018) and in South Khorasan province Tavakoli (2016) to determine soil organic carbon, concluded that organic carbon was reduced by changing the land use of rangeland to cropland.

The result of carbon sequestration rate in the topsoil and subsoil of agriculture farm showed that the higher amount of carbon sequestration in the topsoil in agriculture land use than the subsoil that was in agreement with the finding of Abdi (2005) (Table 2). This is due to positive effect of return of the plant remaining to soil and application of animal manure in the studied farms. Therefore, despite the fact that plowing during years has mixed the soil in the depth of 0 to 30 cm, increase of organic carbon in depth of 0 to 15 cm in comparison with amount of SOC in depth of 15 to 30 cm indicated that cultivation of Damask rose as a stable and covering plant improved the organic carbon in the soil more than cultivation of summer crops and cereals.

In rangeland, amount of organic carbon in the depth of 0 to 15cm with value of 28276 kg/ha was lower than subsoil (depth 15 to 30 cm) with value of 30746 kg/ha Table 2). This indicated the dominant erosion of wind and water in the area resulted in the decreased organic matter and carbon in the topsoil, Gaikani and Abdi (2011) in investigation land use management in Meighan Playa, Iran came to the same conclusion. The surface erosion of soil was evident in the study area and was one of the reasons in the selection of the study area for the international project of carbon sequestration. This erosion could be due to overgrazing by livestock in the study area. In the parts of rangeland where restoration has been done by planting adaptive species, there was a significant increase in phytomass in relation to areas under free grazing by livestock. Therefore, it could be expected that in the coming years, the process of return of the plant remaining to the soil leads to increase in carbon in the surface layer of the soil.

Comparison of carbon sequestration between aerial and underground plant biomass in rangeland land use, indicated that the amount of carbon sequestration in aerial biomass was higher than root biomass (Table 4). Findings of several studies reported the excess of carbon sequestration in aerial biomass than root biomass in rangeland plants (Abdi *et al.*, 2008; Derner *et al.*, 2019). In contrast, for crop lands of cultivated alfalfa, barley and Damask rose, mean of carbon storage in root biomass was higher than the carbon storage in aerial biomass (Table 4). This could be due to that in the aerial organs remains of alfalfa, barley and Damask rose and plowing the fallow farms which resulted in limitation of aerial biomass growth or removal of parts of total produced biomass because of pruning and harvest. Moreover, the results of this study indicated that agricultural land use had more amount of litter in comparison with rangeland; Lack of litter in rangeland was due to low vegetation cover and grazing by livestock, which decreased fall of aerial biomass and production of litter. However, litter production and plant remains were high in croplands of *Rosa damascena*. During the harvest of crops, high amount of vegetation remains as stubble and straw on the surface of the lands consisting litter. Avoidance of vegetation burning of remains or overgrazing in the areas could be a direct increase in carbon sequestration in litter and soil, and avoidance of wind and water erosion.

As it was aforementioned, occurrence of wind and water erosion was evident in the study area. Soil erosion was one of the most important factors in waste of SOC storage. In agriculture land use considering the application of inputs such as irrigation and animal manure, amount of biomass production per year was higher than rangeland which does not have access to this input.

Abdi (2006) showed that in cropland use, considerable amount of biomass is added to soil as litter and rotting roots, which ultimately results in an increase in SOC. Regarding the fact that cultivation of *Rosa damascena* is undergoing in project of carbon sequestration in Mahallat, it is expected that increase in aerial biomass and roots and decrease in erosion improve the sustainable conditions in croplands of the area.

As it is shown in Tables 4 and 5, phytomass in rangeland land use played a less important role than cropland land use. Amount of dried aerial biomass in cropland land use (1592 kg/ha) was significantly higher than the amount of biomass in rangeland land use (260 kg/ha). Total carbon sequestration (including stored carbon in soil, biomass and litter) in cropland land use were higher than rangeland land use. However, this difference was not statistically significant.

In the project area of carbon sequestration in Mahallat, the area of rangelands is 14300 ha (45%) and area of farms is 516 ha (1.6%). Therefore, considering the fact that the area of rangeland is 28 times the farms, rangeland plays a more important role in carbon sequestration. Studied rangelands consisted of five patches with different management practices, including natural and restored rangelands under three grazing conditions (overgrazing, open grazing and exclosure sites). Mean of carbon sequestration in all of these patches was used for comparison with rangeland and cropland land uses.

Based on the amount of carbon in aerial biomass in natural rangelands (225 kg/ha), under grazing rangelands (133 kg/ha) and in exclosure rangelands (443 kg/ha), the exclosure rangelands showed better efficiency in carbon sequestration. Therefore, restoration of rangelands with species such as *Atriplex canescens*, *Zygophyllum atriplicoides* and *Amygdalus scoparia* had a positive effect on increase of aerial biomass. This is expected that continuation of restoration, control and preservation of restored rangeland lead to increase in total carbon sequestration in rangeland ecosystems and therefore, the goals for international project of carbon sequestration in Mahallat are met.

Acknowledgements

We thank Forests, Range and Watershed Management Organization, Iran and Department of Natural Resources and Watershed, Central Province, for constructive suggestions. I thank the anonymous reviewers and Editor for their comments and guidance.

References

Abdi, N., 2005. Estimation of carbon sequestration by Astragalus genus (Tragacanth) in Isfahan and Markazi province. PhD thesis in Rangeland Sciences. Islamic Azad University, Science and Research Branch, Tehran, Iran. 194 pp. (In Persian)

Abdi, N., 2006. Carbon sequestration as an index to sustainable development in natural resources. Proceedings of the 3rd symposium on sustainable development in agriculture. Arak (In Persian)

Abdi, N., Madah-Arefi, H., Zahedi-Amiri, G. 2008. Estimation of carbon sequestration in *Astragalus* rangelands of Markazi province (case study: Malmir rangeland in Shazand region). Iranian journal of range and desert research, 15(2): 269-282. (In Persian).

Ariapour, A., Mehrabi, H., Dehpahlavan, A., 2016. Effects of range reclamation projects on forage production, condition and trend in Khezel rangelands, Nahvand region. Journal rangeland, 10 (1): 1-10. (In Persian).

Ahmadi. A. Gomarian, M. Sanjari, M. 2013. Variations in Forage Quality of Two Halophyte Species, *Camphorosma monspeliaca* and *Limonium iranicum* at Three Phenological Stages, Journal of Rangeland Science, 3(4): 245-250.

Ahmadi, H., Heshmati, G., & Naseri, H. 2015. Soil carbon sequestration potential in desert lands affected two species of Haloxylon aphyllum and Stipagrostis plumosa (Aran-o-Bidgol, Iran). Desert Ecosystem Engineering Journal, 3(5): 29-36.

Badehian, Z., Mansouri, M., 2017. Determine the amount of carbon sequestration in rangeland species (case study: Atriplex canescens). Human and Environment, 15(4): 1-10. (In Persian)

Badehian, Z., Mansouri, M., Azarnivand, H., 2015. Estimation of carbon sequestration capacity and estimating its economic value in Atriplex canescens. Journal of Conservation and Utilization of Natural Resources, 4(1): 117-138 (In Persian) .

Bai, Y., Zhou, Y., & He, H. 2020. Effects of rehabilitation through afforestation on soil aggregate stability and aggregate-associated carbon after forest fires in subtropical China. Geoderma, 376: 114548.

Batjes, N. H., 2019. Technologically achievable soil organic carbon sequestration in world croplands and grasslands. Land degradation & development, 30(1): 25-32.

Chambers, A., Lal, R., & Paustian, K., 2016. Soil carbon sequestration potential of US croplands and grasslands: Implementing the 4 per Thousand Initiative. Journal Soil Water Conservation, 71(3): 68A-74A.

Conant, R. T., & Paustian, K., 2002. Potential soil carbon sequestration in overgrazed grassland ecosystems. Global Biogeochemical Cycles, 16(4): 90-1.

Derner, J. D., & Schuman, G. E., 2007. Carbon sequestration and rangelands: a synthesis of land management and precipitation effects. Journal of soil and water conservation, 62(2): 77-85.

Derner, J. D., Augustine, D. J. & Frank, D. A., 2019. Does grazing matter for soil organic carbon sequestration in the western North American Great Plains? Ecosystems, 22(5): 1088-1094.

Farazmand, S., Heshmati, G., & Naseri, H. 2018. The Effect of Stocking Rate on Carbon Sequestration of *Prangos ferulacea* (Case Study: Gorgou Summer Rangelands, Kohgiluyeh and Boyer-Ahmad Province, Iran). Journal of Rangeland Science, 8(1): 30-40.

Gaikani, S., Abdi, N., 2011. Investigation of the impacts of management and land use on carbon sequestration in the north-west of Meighan Playa. M.Sc. thesis in desert management. Arak Branch. Islamic Azad University. 156 pp. (In Persian)

Gebregergs, T., Tessema, Z. K., Solomon, N., & Birhane, E., 2019. Carbon sequestration and soil restoration potential of grazing lands under exclosure management in a semi-arid environment of northern Ethiopia. Ecology and Evolution, 9(11): 6468-6479.

Ghanbarian, G.A., Hassanli, A., Rajabi, V. 2015. Comparing potential carbon sequestration of different parts of mountain almond and grape plants and soil in Fars province. Journal of Natural Environment, 68(2): 257-265. (In Persian) .

Hasangholi-Pur, H., Imam-dost, H., Mostafa-dost, 2018. Climate change and global warming. The 3rd National Conference on Knowledge and Technology of Agricultural Sciences, Natural Resources and Environment of Iran, 11 March 2019, Tehran, Iran, https://civilica.com/doc. (In Persian) .

Heimsch, L., Lohila, A., Tuovinen, J. P., Vekuri, H., Heinonsalo, J., Nevalainen, O. and Kulmala, L. 2020. Carbon dioxide fluxes and carbon balance of an agricultural grassland in southern Finland. Biogeosciences Discussions, 1-27.

Lal, R., 2002. Soil carbon dynamics in cropland and rangeland. Environmental pollution, 116(3): 353-362.

Lal, R., 2011. Sequestering carbon in soils of agro-ecosystems. Food policy, 36: S33-S39.

Lefèvre, C., Rekik, F., Alcantara, V., & Wiese, L., 2017. Soil organic carbon: the hidden potential. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy. 87pp.

MacDicken, K. G. 1997. A guide to monitoring carbon storage in forestry and agroforestry projects. The Center for Environment, U.S. Agency for International Development and The Winrock Internationl Institute for Agricultural Development, University of California at Berkeley, USA, 87 pp.

Morgan, J. A., Follett, R. F., Allen, L. H., Del Grosso, S., Derner, J. D., Dijkstra, F., Schoeneberger, M. M. 2010. Carbon sequestration in agricultural lands of the United States. Journal of Soil and Water Conservation, 65(1): 6A-13A.

Naghipour, B. A., Dianati, T. G., Tavakoli, H., & Heydarian, A. K. M. 2009. Grazing intensity impact on soil carbon sequestration and plant biomass in semi-arid rangelands (Case study: Sisab rangelands of Bojnord, Iran). Iranian Journal of Range and Desert Research, 16(3): 375-385.

Nosetto, M. D., Jobbágy, E. G., & Paruelo, J. M. 2006. Carbon sequestration in semi-arid rangelands: comparison of Pinus ponderosa plantations and grazing exclusion in NW Patagonia. Journal of Arid Environments, 67(1): 142-156.

Parsamanesh, N., Zarrinkafsh, M., Shahoei, S., Wisany, W., 2015. Effects of land use change on organic carbon amount and some other parameters in vertisols (case study: Bilehvar area, Kermanshah province, Iran). Journal of Hydrology and Soil Science, 8(14): 25-34. (In Persian)

Ramesh, T., Bolan, N. S., Kirkham, M. B., Wijesekara, H., Kanchikerimath, M., Rao, C. S. & Wang, H. 2019.

Soil organic carbon dynamics: Impact of land use changes and management practices: A review. Advances in Agronomy 156: 1-107.

Tavakoli, H. 2016. Potential of carbon sequestration of Hammada salicornica vegetation type in desert areas (Case study: South Khorasan, Iran). Journal of Rangeland Science, 6(1): 24-32.

Zarinkafsh, M., 1993. Applied Soil Science, Evaluation and Morphology and Quantitative Analysis of Soil, Water and Plants. Tehran University, Tehran, Iran, 342 pp. (In Persian) .

مقایسه ترسیب کربن خاک و زیتوده گیاهی در دو کـاربری اراضـی: زراعـی و مرتـع (مطالعه موردی: منطقه گلچشمه محلات، ایران)

فرهاد درخشان[A]، نوراله عبدی[B*]، حمید ترنج زر[C]، عباس احمدی[C]
[A] دانشجوی دکترای تخصصی علوم و مهندسی مرتع، گروه مرتع و آبخیزداری، واحد اراک، دانشگاه آزاد اسلامی، اراک، ایران
[B] دانشیار، گروه مرتع و آبخیزداری، واحد اراک، دانشگاه آزاد اسلامی، اراک، ایران *(نگارنده مسول)، پست الکترونیک: n-abdi@iau-arak.ac.ir
[C] استادیار، گروه مرتع و آبخیزداری، واحد اراک، دانشگاه آزاد اسلامی، اراک، ایران

چکیده: برای بهبود محیط زیست و کاهش تغییرات آب و هوایی، مراتع اصلاح و احیاء شده نسبت به مراتع طبیعی اولویت بیشتری دارند. این مطالعـه بـرای مقایسـه ترسـیب کـربن در خـاک و زیتـوده گیـاهی بـین کاربری‌های مرتعی و اراضی زراعت آبی محلات، استان مرکزی انجام شده است. نمونه‌برداری خـاک بـا حفـر پروفیل (۱۷ کاربری اراضی) در نقاط هدف در دو عمق ۱۵-۰ و ۳۰-۱۵ سانتی متر انجام شد. در هر کاربری از ۳ ترانسکت ۵۰ متری و در امتداد هر ترانسکت از ۴ پلات ۲×۲ متری با فواصـل تصـادفی از هـم اسـتفاده شد. نمونه‌های خاک از مرکز هر ترانسـکت برداشـت گردیـد. مقـادیر کـربن در زیتـوده هـوایی، زیرزمینـی، لاشبرگ و خاک این مناطق محاسبه شد (تابستان ۱۳۹۶). درصد کربن آلی نمونه های گیاهی و درصد کربن آلی خاک در آزمایشگاه به دست آمد. همچنین سایر خصوصیات خاک شامل وزن مخصوص ظـاهری، بافـت خاک، اسیدیته و هدایت الکتریکی تعیین شدند. برای مقایسه ترسیب کربن زیتوده گیـاهی و خـاک بـین دو رویشگاه مرتعی و زراعی از آزمون t مستقل استفاده شد. نتیجه اثـر معنـی‌داری ترسـیب کـربن در بیومـاس گیاهی، لاشبرگ ($P<0.01$) و خاک (معنی دار نبودن) بین کاربری های مرتع و زمین های زراعی نشان داد، کل کربن ترسیب شده در اکوسیستم مرتعی (۵۹۷۴۱ کیلوگرم در هکتار) بیشتر از اراضـی زراعـی (۵۳۳۱۴ کیلوگرم در هکتار) بود. بنابراین میزان ترسیب کـربن در کـاربری‌هـای مرتعـی علـی رغـم عـدم اسـتفاده از نهاده‌های آبیاری و کوددهی در آنها بیشتر از کاربری‌های زراعی منطقه بود.

کلمات کلیدی: کربن آلی خاک، حاصلخیزی خاک، احیای مرتع، استان مرکزی