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Full Length Research Paper

Contribution of soil organic carbon levels, different grazing and converted rangeland on aggregates size distribution in the rangelands of Kermanshah Province, Iran

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Soil Organic Carbon (SOC) plays a major role in nutrient cycling as the primary sink and source of plant nutrients, water holding, soil infiltration, soil aggregation and soil health. This study was conducted in the rangelands of Kermanshah, Iran within five land-use practices including normal rangeland (NR), overgrazed rangeland (OR), fired rangeland (FR), converted rangeland in rain-fed orchard (CRO) and converted rangeland in rain-fed (CRR). 57 soil samples were taken from these sites and subjected to soil samples analyses, especially soil organic carbon (SOC) and aggregate size distribution (ASD). Results showed that the respective mean SOC in the NR, OR, FR, CRO and CRR include 3.32, 1.16, 1.02, 2.13 and 1.22%. There was significantly (P≤ 0.05%) higher in NR than others. Course aggregate class in the NR and CRO were significantly (P≤ 0.05%) more than others due to light grazing and higher SOC while fine aggregate size was found significantly different from each other. Fine aggregate size was higher in the CRR (20.42 %) and OR (18.40 %) compared to NR. It occurs through, up to down the slope plough and lower SOC value. The fire and overgrazing are second and third improper activities which negatively affect SOC and soil aggregation.

Key words: Aggregate size distribution, normal rangeland, soil organic carbon, different grazing, converted rangeland.

INTRODUCTION

Soil Organic Carbon (SOC) plays a major role in nutrient cycling as the primary sink and source of plant nutrients, water holding, soil infiltration, soil aggregation and soil health (Lal, 1998; Youjun et al., 2007). Due to its multi-functions, SOC depletion results from both on- and off-site impacts of land degradation, especially carbon dioxide (CO_2) emission. The CO_2 emission contributes to serious climate changes such as global warming, making anthropogenic carbon flux a main concern among relevant experts and decision makers during last and current decades. There are several sources for CO_2 emission such as fossil fuel combustion and agricultural activities, as well as soil degradation. It is estimated that CO_2 concentration in the atmosphere has been increasing from 285 ppm at the end of the nineteenth century to

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Abbreviations: CRR, converted rangeland in rain-fed; **CRO,** converted rangeland in rain-fed orchard; **FR,** fired rangeland; **NR,** normal rangeland; **OR,** overgrazed rangeland; **SOC,** soil organic carbon.

about 366 ppm in 1998 (FAO, 2001). Plant residue is the main source of SOC in the semi-arid regions which can enhance macro aggregates (0.25 to 50 mm) of the soil. Baladok (2000) reported that small micro aggregates (<0.05 mm) were held together by SOC while macro aggregates were stabilized by rooting and plant residue. The SOC level in soil was related to chemical, physical and biological properties. However, it is affected mainly by soil physical characteristics especially soil aggregates.

The contribution of coarse soil aggregates in absorbing SOC is more than in micro aggregates (<0.05 mm), but it is damaged by improper agricultural activities (such as heavy tillage practices, burning of crop residue), grazing and forest clearance. Furthermore, the coarse soil aggregates are reduced mainly by long-term conventional tillage practices. Li and Pang (2010), studying a silty clay loam soil in China revealed that long-term (33 years) practices of this tillage reduced 22% of coarse aggregates and adversely increased 34% of fine aggregates. In contrast, converting the cropland to the forest and orchard enhanced 10% of coarse aggregates which subsequently enhanced 40 to 76% of SOC and N in the soil. A decrease in soil aggregate stability resulted in the breakdown of soil structure which can occur either externally under the impact of rain or internally due to the escape of trapped air when aggregates are heavily soaked (Gabriels et al., 2004). Yan et al. (2008) reported that most of the soil aggregates are broken through inter-rill erosion in the Ultisols in China. Among main land-use practices, the rangeland plays an important role in C sequestration due to covering a large area in the world. It is managed mainly for livestock production covering more than one-quarter of the world's lands (Asner et al., 2004). Furthermore, rangeland soil has considerable potential SOC contributing to reduction of greenhouse gas emissions (Lal, 2004).

Management practices affect C level and consequently soil chemical and physical characteristics, and indirectly change plant morphology and microbial activities (Jones and Donnelly, 2004; Steenwerth et al., 2002; Stromberg and Griffin, 1996). Management-induced changes to C cycling at local scales can also affect the global C cycle (Conant and Paustian, 2001; Schimel et al., 1990). Unsuitable agricultural activities and land-use alteration such as heavy tillage practice, over grazing, forest clearance and crop residues burning contribute to SOM depletion and consequently CO_2 emission. Deforestation, biomass burning (such as charcoal production) and soil plowing enhances mineralization of SOC and releases CO_2 into the atmosphere (Jennifer et al., 2004). Although, SOC depletion is mainly correlated with rainfall intensity and vegetation cover, the land use pattern and soil erosion play an important role in the variability of SOC and its dynamics (Lal, 2004). The improper land use activities resulted in the removal of the litter layer and an increase in soil erosion and sedimentation (Collin and Kuehl, 2001).

SOC losses in the Mediterranean areas correlate with soil erosion. Morsli et al. (2006) reported that in these areas, depletion of SOC through soil erosion was more vulnerable, where soil erosion was severe on the bare soil (136 kg C $ha^{-1}year^{-1}$), while there was less than 42 kg C $ha^{-1}yearr^{-1}$ on the vegetated plots. Tillage practice through moldboard plow can expose and displace most of the top-soil resulting in SOC depletion. This plow tool can displace soil three times more than the chisel tillage (Morgan, 2005). It is used widely in mountainous areas of Iran even for converting forests and rangelands to rain-fed areas, contributing in this way to significant decline in soil organic matter in the Oak forests (Vacca et al., 2000). In addition, the crop residues are burnt for continued cultivation without fallow period. Crop residue burning reduces organic carbon levels in the topsoil layer and expose P and K in surface soil that easily enter in the run-off (Bertol et al., 2007).

About 80% of the agricultural lands worldwide are damaged by moderate to severe soil erosion resulting in nutrient deficiency and SOC loss (Titi, 2003). Displacement and depletion of SOC in the steep slope and hilly areas is more sever. Karlen et al. (2008) reported that 60% of declined SOC was removed from hill-top and displaced in the drainage system due to tillage practices. Some mismanagement practices in the semiarid rangelands including overgrazing, converted rangelands into rain-fed orchard which eventually destroyed the carbon stocks of the rangelands. The objectives of this study were: i) to analyze the effects of different management practices on the SOC contents; and ii): to compare the aggregate size distribution in the different land-use practices of rangelands.

MATERIALS AND METHODS

The study area

This study was conducted in Kermanshah province which is located in the west of Iran (33° 06' to 35° 15' N and 45° 24' to 48° 30' E) with an area of 25000 km^2 (Figure 1). The population of this province is considerable including about 1.9 million people in 2006, 33% of whom are settled in the rural areas. This province is mainly mountainous with hilly areas of different elevations (270 to 3450 m above the sea level) while there are also vast plains occupied by agriculture, industries and urban areas. The average annual precipitation and temperature are 470 mm and 14.8°C respectively. Main land-use comprises of rangelands, forests and agriculture which certainly are characterized by *Astragalus* gossypinus, *Quercus persica* and *wheat plants*, respectively. However, the soil properties are mainly inherited from geological characteristics especially high level of calcite and fine grained materials due to the limestone, marl and clay stone in most layers of geological formations.

Site selection and land use patterns

Seven sites of rangelands in the Kermanshah province were selected for these studies (Figure 1) which were categories in different land-use practices: i) Normal rangeland (NR); ii) over-

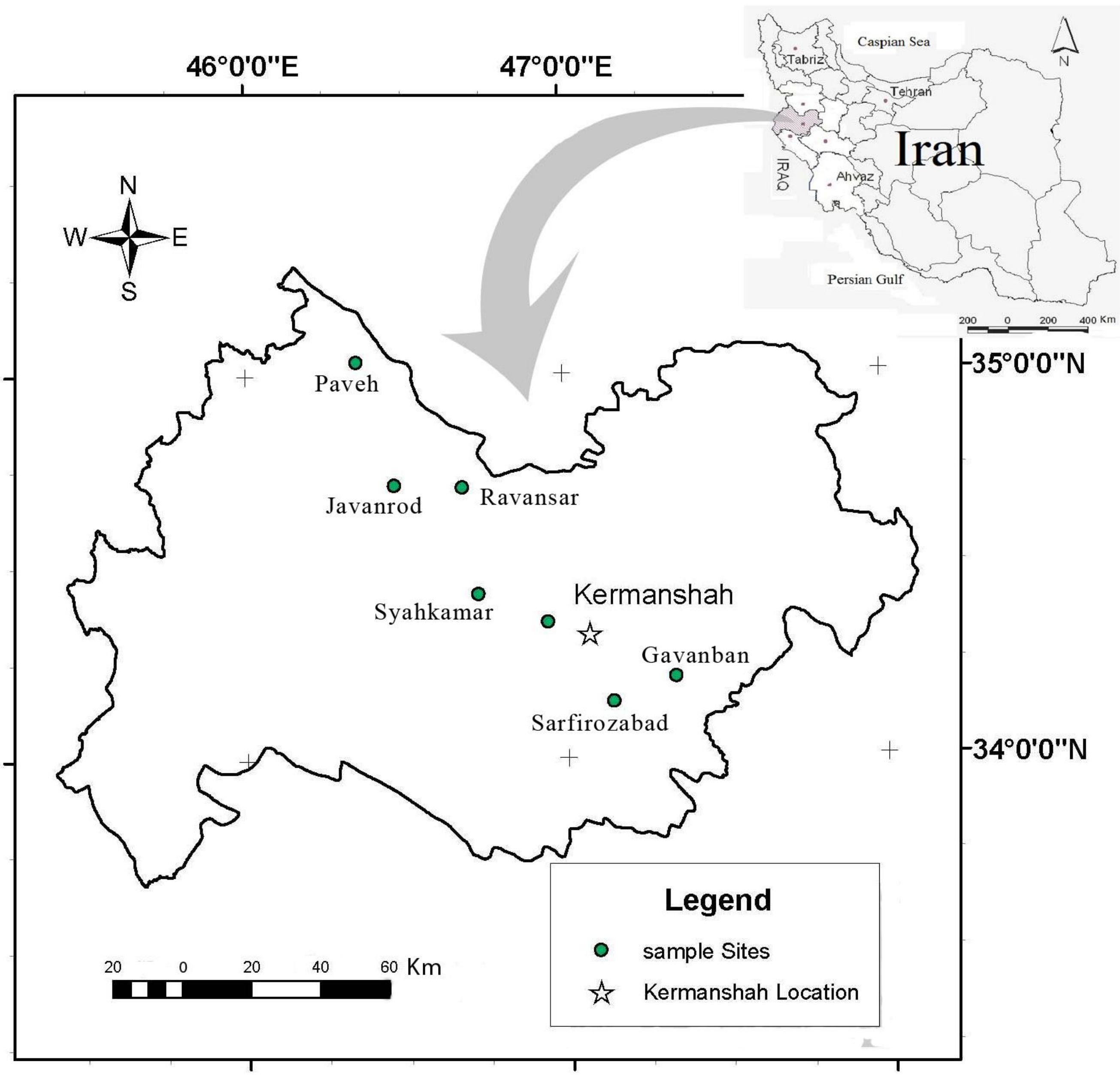

Figure 1. Location of study area (Kermanshah province) in Iran.

grazed rangeland (OR); iii) fired rangeland (FR); iv) converted rangeland in rain-fed orchard (CRO); and v) converted rangeland in rain-fed (CRR).

Soil sampling and analyses

57 soil samples were taken from 0 to 20 cm depth during September to November 2010 in the five land-use patterns as was described in site selection and land use patterns. The soil samples were air-dried and sieved through 2 mm mesh for physico-chemical analyses including particles size distributions, aggregate size distribution, soil organic carbon, pH, EC and calcite. The hydrometer method (FAO, 1974) was used for determination of soil particles size distributions as outlined by Ryan et al. (2001). Soil aggregate distribution was determined using wet sieving. 50 g soil (< 5 mm) was subject to soil aggregates analysis. The aggregates were categorized into five size fractions including very coarse (5.0 to 2.0 mm), coarse (2.0 to 1.0 mm), moderate (1.0 to 0.250 mm), fine (0.250 to 0.05 mm) and very fine (<0.05 mm). Organic carbon was determined by the Walkley and Black method (Nelson and Sommers, 1982) for each soil aggregate category. The pH of soils was measured by saturated paste method as outlined by Ryan et al. (2001).

Electrical conductivity (EC) was measured by extracting the soil samples with water (1:1 water ratio) (Ryan et al., 2001). The carbonate of soil samples was measured by titration method using sodium hydroxide solution (Nelson and Sommers, 1982).

Statistical analysis

The statistical analyses including ANOVA and regression carried out using SPSS software (version 19). Means comparing analysis was done between soil variables of each site and index site (normal rangeland) through one-way ANOVA (NSK procedure) at P = 0.05.

RESULTS AND DISCUSSION

Land-use practices properties

Normal rangeland (NR) is characterized by natural vegetation cover, relatively good condition, light animal grazing and low soil erosion. Respective elevation ranges, average slope, main slope direction and mean annual precipitation are 1500 to 2245 m (above sea level), 30%, northern aspect and 500 mm. Soil depth in this site is shallow mainly about 40 cm:

i) Overgrazed rangeland (OR) that suffered livestock overgrazing, diminishing of desirable plant species such as *Festuca ovina* and *Medicago sativa* (plant biodiversity reduction), compacted soil due to heavy animal traffic (through animal's hooves), high potential of run-off, soil erosion hazard, especially inter-rill and rill erosions. The vegetation cover of this is dominated by annual grasses. Soil is relatively deeper, but stoniness and gravels at the surface soil are considerable. Average annual precipitation is 550 mm and minimum and maximum altitudes above sea level include 1533 to 2153 m with both northern and southern slope directions.
ii) Fired rangeland (FR) that during last 10 years was subject to annual fire incidence especially arson fires. During field verification, it was seen that both vegetation and surface soil have been negatively affected by fire. Bare soil and gravels were more apparent than plant cover. Most parts of biannual and perennials plants were diminished by fire while annual plants species dominated in the site. Topographical conditions are almost the same as OR site.
iii) Converted rangeland in rain-fed orchards (CRO) which for more than 10 years are planted by almond trees and vineyards. These areas mainly located in vicinity of smallholder's lands. Field survey showed that surface water is harvested through simple micro catchments for supplemental irrigation. Average elevation is 1547 m above sea level and is dominated by northern slope aspect. The slope steepness varies from 10 to 40% which is highest in Paveh site and gentle in Ravansar site (Figure 1).
iv) Converted rangeland in the rain-fed (CRR) that carried out mainly during recent 10 years. Land-use pattern in this site characterized by up-down the slope tillage, annual crops (wheat, barley, and chickpea) cultivation and low crops yield due to shallow soil depth and hill slope. It was seen that this site contribute to siltation problem due to improper tillage practices. It is a common activity in the western part of Iran which is due to considerable annual precipitation (about 450 mm/yr) contributing to soil erosion hazard (inter-rill and rill erosion) and high runoff coefficient. The distributions of these sites are shown in Figure 1.

Effects of land-use practices on soil characteristics

Soil organic carbon

Soil organic carbon (SOC) levels in the different land-use practices are presented in Table 2. Mean level of SOC in the NR, OR, FR, CRO and CRR are 3.32, 1.16, 1.02, 2.13 and 1.22% respectively. The difference between minimum and maximum levels of SOC were found as 0.68 and 3.93% in OR and NR, respectively. The ANOVA analysis of SOC among land-use practices explored that there were three significant levels of SOC for land-use practice ($P \leq 0.05\%$). The lower SOC value belong to OR, FR and CRR while this value in the NR is significantly higher than others. In addition, this value for CRO was moderate among these sites (Table 1). The highest level of SOC in the NR (3.32%) is related to considerable vegetation cover that was found more than 60% during field verification as well as low soil erosion hazards. The study of Schuman et al. (2002) showed that proper grazing management in the USA enhanced 100 to 300 kg/ha/year soil organic carbon which was up to 600 kg/ha/year for new grasslands. In contrast, fire, heavy grazing and up-down slope tillage practices resulted in significant reduction of SOC in FR, OR and CRR sites, respectively which negatively affect balance between input and fluxes of SOC.

The effect of different land use type on organic matter content is dependent on a balance between organic matter inputs and the degradative effect of the way of tillage and reaping (Liu et al., 2006). Also, an investigation by Li et al. (2008) showed that heavy sheep grazing decreased about 16.5 kg of OC per ha.

Calcite

The respective average level of calcite in CRO, OR, NR, CRR and FR were 11.76, 13.25, 16.94, 18.37 and 19.66%. The minimum and maximum calcite content were found in the rain-fed orchard and fired rangeland, respectively. Statistical analyses showed that there was no significant difference ($P \leq 0.01\%$) among all sites for soil calcite variable (Table 3). It is due to geological properties which are dominated by calcareous sedimentary formations. High level of calcite consequently affects pH that is alkaline in all sites.

Soil pH

As given in Tables 2 and 3, mean soil pH in the study

Table 1. Mean, minimum, maximum, SD, CV and Skewness of soil variables of rangeland in Kermanshah province, Iran.

Soil variable		Land-use	Mean	Min.	Max.	SD	CV (%)	Skewness
		NR	3.32	1.94	3.93	0.64	0.41	-1.08
		OR	1.16	0.68	1.63	0.28	0.08	0.02
OC (%)		FR	1.02	1.14	2.47	0.44	0.19	0.97
		CRO	2.13	1.23	3.73	0.81	0.66	0.67
		CRR	1.22	0.84	2.01	0.35	0.12	1.02
		NR	16.94	3.00	54.80	16.47	271.13	1.24
		OR	13.25	3.80	21.70	5.58	31.19	-0.19
Calcite (%)		FR	19.66	4.00	47.40	15.70	246.57	0.78
		CRO	14.99	6.50	48.00	12.08	145.86	2.71
		CRR	18.38	6.00	32.50	9.57	91.585	0.31
		NR	7.41	7.14	7.79	0.18	0.03	0.71
		OR	7.64	7.43	7.90	0.16	0.02	0.44
pH		FR	7.61	7.51	7.78	0.08	0.08	0.69
		CRO	7.65	7.47	7.76	0.09	0.09	-0.82
		CRR	7.63	7.38	7.82	0.12	0.01	-0.56
		NR	0.59	0.40	0.78	0.12	0.01	0.12
		OR	0.47	0.29	0.62	0.11	0.01	-0.24
EC (dSm^{-1})		FR	0.59	0.50	0.67	0.06	0.01	-0.20
		CRO	0.46	0.30	0.60	0.11	0.01	-0.36
		CRR	0.49	0.35	0.71	0.13	0.02	0.96
		NR	30.81	11.81	72.23	17.31	299.58	0.96
		OR	24.04	15.24	32.83	4.28	18.30	-0.13
	2-5 (mm)	FR	30.53	6.20	47.63	12.11	146.66	-0.34
		CRO	7.21	0.90	13.16	3.76	14.12	0.06
		CRR	7.41	3.46	16.90	3.65	13.35	1.38
		NR	13.67	4.80	20.65	5.41	29.26	-0.16
		OR	16.01	10.10	19.94	3.07	9.42	-0.41
	1-2 (mm)	FR	35.50	15.92	65.58	16.34	266.83	0.41
		CRO	18.39	10.82	28.06	6.75	45.52	0.29
		CRR	16.43	8.07	23.83	5.35	28.59	-0.26
		NR	13.61	3.73	30.14	8.80	77.37	0.71
		OR	21.11	13.24	29.02	4.84	23.41	-0.15
Aggregate size distribution (%)	0.250-1 (mm)	FR	40.83	33.57	58.84	7.76	60.14	1.54
		CRO	11.92	4.72	27.00	7.50	56.23	1.14
		CRR	12.53	5.58	20.02	4.75	22.56	0.35
		NR	21.55	7.63	36.60	11.05	122.10	-0.04
		OR	22.16	13.52	31.18	6.58	43.24	-0.09
	0.05-0.25 (mm)	FR	33.15	21.77	53.82	10.94	119.61	0.76
		CRO	13.59	2.66	24.64	7.92	62.69	-0.16
		CRR	9.55	7.40	18.82	3.40	11.55	2.71
		NR	11.80	5.32	21.38	5.44	29.60	0.39
		OR	15.29	12.37	21.90	2.95	8.71	1.30
	>50 (mm)	FR	34.37	17.54	58.44	15.20	231.03	0.53
		CRO	20.42	9.63	32.53	8.63	74.52	0.06
		CRR	18.12	7.35	24.60	5.57	31.04	-0.99

Table 2. Soil EC, pH, calcite, SOC, SPD and aggregate size distribution in different land-use practices of rangeland in Kermanshah province, Iran.

Land-use	Ec (mDm^{-1})	pH	Calcite (%)	SOC[1] (%)	SPD[2] (%)			Aggregate size distribution (%)				
					Sand	Silt	Clay	2-5 (mm)	1-2 (mm)	0.25-1 (mm)	0.05-0.50 (mm)	< 0.05 (mm)
Normal rangeland	0.78	7.04	3	3.85	14.2	.51.0	34.8	15.96	20.00	38.35	12.91	12.77
	0.4	7.5	3.2	3.84	26.2	55.4	18.4	26.96	22.06	32.16	11.12	7.70
	0.75	7.36	3	3.2	11.2	48	40.8	72.23	15.24	6.20	0.90	5.42
	0.55	7.73	17	2.66	9.6	51	39.4	19.18	23.79	40.74	6.37	9.92
	0.64	7.68	22.5	1.94	9.2	44	46.8	16.55	18.13	35.25	13.16	16.90
	0.62	7.45	5	3.74	13.2	44	42.8	52.44	23.12	15.22	3.16	6.06
	0.59	7.61	4.5	2.22	11.6	48	40.4	35.45	32.83	20.84	7.35	3.52
	0.6	7.76	6.5	3.93	17.6	50	32.4	13.14	22.70	45.22	11.07	7.86
	0.52	7.76	6.5	3.89	18	46	36	38.32	25.27	25.86	4.97	5.58
	0.48	7.6	8.5	3.7	10	32	58	45.04	24.58	23.10	2.30	4.98
	0.75	7.59	14	3.8	22	40	38	11.81	25.46	47.63	7.02	8.08
	0.47	7.76	26.5	3.68	24	40	36	14.42	25.77	44.93	7.10	7.79
	0.72	7.6	34.8	3.16	19.2	40	40.8	22.28	25.22	36.23	8.73	7.54
	0.24	7.17	54.8	3.36	14.8	42.4	42.8	39.61	27.71	21.22	8.00	3.46
	0.57	7.21	44.3	2.89	22	33.5	44.5	38.82	28.72	24.97	3.96	3.52
Overgrazed rangeland	0.38	7.59	20	1.25	3.2	43.4	53.4	11.59	14.44	51.49	10.82	11.65
	0.29	7.9	21.7	0.9	2.2	40.4	57.4	4.80	10.10	65.58	11.45	8.07
	0.36	7.81	14.5	0.96	1.1	38.4	60.4	20.02	18.76	38.42	11.60	11.20
	0.42	7.8	6.75	0.68	1.2	69.6	29.2	7.95	13.76	40.76	18.09	19.44
	0.62	7.53	11.2	1.25	3.2	38.4	58.4	11.67	19.94	42.80	14.02	11.57
	0.56	7.54	16	1.47	4.2	39.4	56.4	9.68	15.59	40.69	14.92	19.13
	0.46	7.43	3.8	1.63	8	36	56	19.21	14.86	19.77	23.99	22.16
	0.56	7.48	13.7	1.05	13	27	60	20.65	15.17	15.92	24.42	23.83
	0.48	7.6	15.4	1.1	23	29	48	14.86	17.77	20.55	28.06	18.77
	0.55	7.7	9.5	1.29	20	43	37	16.23	19.75	19.06	26.49	18.47
Fired rangeland	0.65	7.51	47.4	1.14	11.2	49.4	39.4	7.01	13.24	41.60	18.13	20.02
	0.67	7.56	5.2	1.45	21.2	29.4	49.4	3.73	17.91	58.84	9.58	9.94
	0.65	7.52	9.5	1.25	17	34	49	4.94	15.07	38.43	27.00	14.56
	0.56	7.59	19	1.21	13.2	38.4	48.4	15.07	20.70	47.48	8.76	7.98
	0.63	7.71	40.5	1.49	15.2	46.4	38.4	30.14	25.60	33.95	4.73	5.58
	0.59	7.78	33	2.12	17.2	38.8	44	20.25	23.58	37.29	9.65	9.23
	0.57	7.56	4	2	9.2	40	50.8	15.13	29.02	38.24	7.09	10.53
	0.52	7.66	22	1.56	11.6	43	45.4	23.40	23.68	34.79	4.72	13.40
	0.58	7.62	7	2.47	9.6	45	45.4	9.72	22.95	44.08	8.59	14.66
	0.5	7.64	9	1.42	11	44	45	6.74	19.36	33.57	20.95	19.38
Converted rangeland into rain-fed orchard	0.32	7.47	0.5	2.05	4	37.2	58.8	36.60	30.58	21.77	2.66	8.39
	0.3	7.6	2.5	2.2	3.6	30	66.4	34.38	31.18	23.70	3.22	7.52
	0.51	7.69	1.25	2.51	2	37.2	60.8	32.24	26.39	26.65	4.63	10.08

Table 2. Contd.

	0.54	7.71	48	2	24	48	28	19.12	18.70	41.64	13.14	7.40
	0.35	7.66	15	0.83	30	26	44	7.63	13.73	53.82	16.83	7.99
	0.4	7.61	16.4	0.97	22	30	48	18.27	23.26	26.02	24.64	7.81
	0.55	7.68	12.5	1.08	20	31	49	9.10	15.20	41.52	24.04	10.14
	0.6	7.76	6.5	3.73	18	50	32	7.70	13.52	42.98	16.98	18.82
	0.52	7.76	6.5	3.39	18	46	36	27.38	25.01	23.93	14.57	9.12
	0.48	7.6	8.5	2.52	11	32	57	23.05	24.04	29.47	15.17	8.26
Converted rangeland into rain-fed crop	0.71	7.48	15.3	1.18	3.2	51	45.8	5.99	17.11	58.44	11.10	7.35
	0.45	7.38	8.3	1.22	2.2	49	48.8	6.1	13.12	38.38	19.98	22.42
	0.44	7.57	10.2	1.56	5.2	40.4	54.4	5.32	19.64	45.69	11.03	18.33
	0.46	7.65	12.5	1.16	3.6	54	42.4	8.74	13.89	54.74	14.25	8.38
	0.71	7.66	9	1.39	9.6	54	36.4	6.60	12.97	53.89	11.96	14.58
	0.69	7.56	6	2.01	7.2	46	46.8	21.38	21.90	27.96	9.63	19.15
	0.43	7.82	31	1.1	12	46	42	16.74	12.96	29.04	20.30	20.95
	0.5	7.76	21.5	1.52	15.2	39	45.8	13.02	15.74	25.07	29.07	17.10
	0.35	7.64	21.25	0.93	10.4	37	52.6	10.67	12.37	22.57	29.96	24.43
	0.4	7.64	21.75	0.84	7.2	44	48.8	19.01	15.08	17.54	28.56	19.80
	0.37	7.66	31.25	0.85	5.4	39	55.6	13.64	15.36	18.17	32.53	20.31
	0.37	7.7	32.5	0.93	8.4	44	47.6	14.38	13.38	20.92	26.72	24.60

*SOC = soil organic carbon, **SPD = soil particles distribution and ***soil sampling at the top-soil (0 to 20 cm).

Table 3. The ANOVA analyses of soil variables in the different land-use practices of rangeland in Kermanshah province, Iran.

Soil variable		**Land-use practice**					**Sig.**
		NR[1]	**OR**[2]	**FR**[3]	**CRO**[4]	**CRC**[5]	
SOC (%)		3.3240$^{(b)}$	1.1580$^{(a)}$	1.2242$^{(a)}$	2.2630$^{(ab)}$	1.6110$^{(a)}$	0.000
Calcite (%)		11.7650$^{(a)}$	13.2550$^{(a)}$	16.9400$^{(a)}$	18.3792$^{(a)}$	19.6600$^{(a)}$	0.613$^{(NS)}$
pH		7.5213$^{(a)}$	7.6150$^{(a)}$	7.6267$^{(a)}$	7.6380$^{(a)}$	7.6540$^{(a)}$	0.212$^{(NS)}$
EC (mDm^{-1})		0.4570$^{(a)}$	0.4680$^{(a)}$	0.4900$^{(a)}$	0.5787$^{(a)}$	0.5920$^{(a)}$	0.020
Aggregate size distribution (%)	2-5 (mm)	30.814 $^{(b)}$	13.666$^{(a)}$	13.614$^{(a)}$	21.547$^{(b)}$	11.799$^{(a)}$	0.000
	1-2 (mm)	24.043$^{(b)}$	16.014$^{(a)}$	21.111$^{(b)}$	22.161$^{(b)}$	15.293$^{(a)}$	0.000
	0.25-1 (mm)	30.528$^{(a)}$	35.505$^{(a)}$	40.827$^{(a)}$	33.151$^{(a)}$	34.368$^{(a)}$	0.414$^{(NS)}$
	0.05-0.50 (mm)	7.208$^{(a)}$	18.386$^{(bc)}$	11.920$^{(ab)}$	13.588 $^{(abc)}$	20.424$^{(c)}$	0.000
	< 0.05 (mm)	7.407$^{(a)}$	16.429$^{(cd)}$	12.528$^{(bc)}$	9.553$^{(ab)}$	18.116$^{(d)}$	0.000

[1] NR = Normal rangeland, [2] OR = overgrazed rangeland, [3] FR = fired rangeland, [4] CRO = converted rangeland into orchard, [5] CRC = converted rangeland into rain-fed, NS = no significant.

area is 7.4 indicating the moderate alkaline soil and there was no significant difference (P ≤ 0.05%) in all the sites. However, average pH was 7.41 (NR), 7.64 (OR), 7.61 (FR), 7.65 (CRO) and 7.63 (CRR). Alkaline pH value in Kermanshah Province is related to geological formation properties which mainly comprise limestone especially in surface layers. The semi-arid regions of Iran soils are moderately alkaline with pH value of 7.4 to 8.4 (Marx et al., 1999; Heshmati et al., 2011).

Soil EC

The minimum and maximum soil EC levels in the different management practices are 0.45 to 0.78 mDm^{-1} indicating low EC in the study area (Table 2). The respective soil EC for NR, OR, FR, CRO and CRR are 0.59, 0.47, 0.59, 0.46 and 0.49 mDm^{-1} with no significant difference (P ≤ 0.05%) among these land-use practices. This result showed that susceptibility of these soils to salinity hazard is low. The soil with low EC (less than 2 dSm^{-1}) is categorized as the non-saline soil whose salinity effects are mostly negligible (Hazelton and Murphy, 2007).

Aggregate size distribution

Aggregate size distribution including 2.0 to 5.0, 1.0 to 2.0, 0.250 to 1.0, 0.050 to 0.250 and <0.05 mm are explained as follows:

Very course aggregate (2 to 5 mm)

As shown in Table 3, there are verities of very course aggregate proportion in the land-use practices of study areas. Mean percentage of this aggregate size in the NR, OR, FR, CRO and CRR include 30.81, 13.66, 13.61, 21.54 and 11.79%, respectively. The maximum value of this category was found in NR (72.23%). The ANOVA analysis explored that there are two significant levels for very course aggregates. This aggregate class in the NR and CRO were significantly (P≤ 0.05%) more than other sites (Table 3). It is clear that the high proportions of this aggregate size in the NR and CRO are related to SOC which was found significantly higher than other areas indicating the effect of management system, especially in top-soil. Differences in SOC between management systems were most evident in the top 0 to 0.20 m (Eynard et al., 2005).

Course aggregate (1 to 2 mm)

ANOVA analysis for course aggregate size (1 to 2 mm) distribution among different land-use management revealed that there are significant difference (P ≤ 0.05%) between NR, CRO and FR compared to OR and CRR (Table 3). The frequencies minimum to maximum of this aggregate size in order includes ORR (15.29%), OR (16.01%), FR (21.11%), CRO (22.16%) and NR (24.04%) indicating good condition for converting rangeland to orchard and normal rangeland in view of soil quality. Enhancing aggregate size in these two practices is due to an absence of tillage practices as well as relative high level of SOC as shown in Table 3. Enhancing the courser aggregates such as NR indicates a soil with the good quality that is mainly related to land-use management. Large aggregates are more sensitive to management effects and greater proportions of large aggregates indicate increase in soil quality (USDA, 2008).

Moderate aggregate (0.250 to 1 mm)

Mean percentage size distribution of moderate aggregate (0.250 to 1.00 mm) in NR, OR, FR, CRO and CRR include 30.52, 34.50, 40.82, 33.15 and 34.36%, respectively indicating high level of this size class in all sites compared to other aggregate sizes distribution. It is relatively lower in the NR while it is highest in the FR (Table 3). The lower and high levels of these aggregate sizes are due to considerable percentage of very coarse and coarse aggregate sizes in NR and adversely high amount of finer aggregate size in FR. The statistical analysis also explored that there was no significant difference (P≥ 0.44%) among all land-use practices (Table 3). This result indicates that soil aggregate size distribution is not affected by land-use practices, although SOC in these sites was not at the same levels.

Fine aggregate (0.050 to 0.250 mm)

In contract to moderate aggregates, fine aggregates in all land-use were found at a low ratio. The respective frequency of this category in the NR, OR, FR, CRO and CRR were 7.21, 18.40, 11.92, 13.60 and 20.42%, respectively (Table 3). The ANOVA analysis showed that there are 3 different sub groups for fine aggregate size which were found significantly different (P ≤ 0.057%) from each other. It was high respective to the level NR and FR. But there is intermediate level CRO (Table 3). The highest proportion of fine aggregates in CRR has occurred through improper tillage practice which is mainly characterized by up to down the slope plough. Field verification showed that this tillage practice is done by moldboard plow tool. That tillage system contribute to the destruction of soil aggregates, specially course aggregate size as well as displacement of soil particles in the hilly areas (Morgan, 2005).

Very fine aggregate (< 0.050 mm)

As revealed in Tables 3 and 4, percentage of very fine aggregates within each land-use practice and among all sites is roughly the same as fine aggregates. There is lowest value for NR while it is highest level in CRR site. The critical levels (18.12 and 16.43%) occurred through tillage and animal traffic (animal hooves) affect CRR and OR. The study by Hevia et al. (2003), in the agricultural areas of Argentina showed that linear decrease in SOC correlated with loss of fine soil aggregates due to erosion in continuous conventionally tilled.

Conclusion

Both soil aggregation and SOC are affected by different land-use practices in the rangelands of Kermanshah Province. Although, tillage practice is an illegal activity in the rangelands of Iran, it contributes to damage soil physical properties. The CRR activity causes significant reduction of SOC compared to other land-use practices. It also negatively influences soil aggregate size distribution reducing coarse and very coarse aggregates and adversely enhancing the fine aggregate size. Furthermore, after tillage practice, fire and overgrazing are second and third improper activities which negatively affect both SOC and soil aggregation. It is concluded that respective proper land-use practices were found in normal rangelands (characterized by light grazing) where orchard construction resulted in enhancing the SOC value as well as course soil aggregate ratio.

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REFERENCES

Asner GP, Elmore AJ, Olander LP, Martin RE, Harris AT (2004). Grazing systems, ecosystem responses, and global change. Annu. Rev. Env. Resour., 29: 261–299.

Baladok, JA (2000). Soil Organic Matter. In: Sumner ME (eds) Handbook of Soil Science. CRC Press, New York, pp. B-25-71.

Bertol I, Engel FL, Mafra AL, Bertol OJ, Ritter SR (2007). Phosphorus, potassium and organic carbon concentrations in run-off water and sediments under different soil tillage systems during soybean growth. Soil Tillage Res., 94: 142-150.

Collin ME, Kuehl RJ (2001). Organic Matter Accumulation and Organic Soil CRC Press, New York.

Conant RT, Paustian K (2001). Potential soil carbon sequestration in overgrazed grassland ecosystems. Global Biogeochemical Cycles (in preparation).

Eynard A, Schumacher TE, Lindstrom MJ, Malo DD (2005). Effects of agricultural management systems on soil organic carbon in aggregates of Ustolls and Usterts. Soil Tillage Res., 81: 253-263.

FAO (2001). Production Yearbook. Food Agric. Organ., Rome, Italy.

FAO (1974). The Eupharate Pilot Irrigation Project. Methods of soil analysis, Gadeb Soil Lab. Food Agric. Organ., Rome.

Gabriels D, Schiettecatte W, Verbist K, Cornelis W (2004). Water Harvesting in Southeast Tunisia and Soil Water Storage in the Semi-arid Zone of the LoessPlateou of China. In: Thomas S (eds) 2nd International Workshop of Combating Desertification: Sustainable Management of Marginal Drylands. UNESCO-MAB drylands Series No. 3, Shiraz (Iran), pp. 19-24.

Hazelton P, Murphy B (2007). Interpreting Soil Test Results. CSIRO Publisher Sydney.

Heshmati M, Arifin A, Shamshuddin J, Majid NM, Ghaituri M (2011). Factors affecting landslides occurrence in agro-ecological zones in the Merek catchment, Iran. J. Arid Environ., 75 (2011): 1072e1082.

Hevia GG, Buschiazzo DE, Hepper EN, Urioste AM, Anton EL (2003). Organic matter in size fractions of soils of the semiarid Argentina. Effects of climate, soil texture, and management. Geoderma, 116: 265–277.

Jennifer SP, Readw JM, Denslow JS, Guzman SM (2004). Estimating Soil Carbon Fluxes Following Land-Cover Change: A Test of some Critical Assumptions for a region in Costa Rica. Global Change Biol., 10: 170–181.

Jones MB, Donnelly A (2004). Carbon sequestration in temperate grassland ecosystems and the influence of management, climate and elevated CO2. New Phytologist, 164: 423-439.

Karlen DL, Tomer MD, Neppel J, Cambardella CA (2008). A preliminary watershed scale soil quality assessment in north central Iowa, USA. Soil Tillage Res., 99: 291-299.

Lal R (2004). Soil carbon sequestration to mitigate climate change. Geoderma, 123(1-2): 1-22.

Lal R (1998). Soil Quality and Sustainability. In: Lal R, Blum HW, Valentine C, Stewart BA (eds) Methods for Assessment of Soil Degradation. CRC Press, New York, pp. 17-31.

Li C, Hao X, Zhao M, Han GW (2008). Influence of historic sheep grazing on vegetation and soil properties of a desert steppe in Inner Mongolia. Agric. Ecosystems Environ., 128: 109-116.

Li GL, Pang XM (2010). Effect of land-use conversion on C and N distribution in aggregate fractions of soils in the southern Loess Plateau, China. Land Use Policy, 27: 706-712.

Liu DW, Wang ZM, Zhang B, Song KS, Li XY, Li JP, Li F, Duan HT (2006). Spatial distribution of soil organic carbon and analysis of related factors in croplands of the black soil region, Northeast China. Agric. Ecosyst. Environ, 113: 73-81.

Marx, EX, Hart J, Stevens RG (1999). Soil Test Interpretation Guide Oregan state University Press, Oregan, USA.

Morgan RPC (2005). Soil Erosion and Conservation. Blackwell Publisher, Oxford, London.

Morsli B, Mazore M, Arabi M, Mededjel N, Roose E (2006). Influence of land use, soils, and agricultural practices on erosion, eroded carbon, and soil carbon stocks at the plot scale in the Mediterranean of Northern Algeria. In: Roose EJ, Lal R, Bartes B, Stewart BA (eds) Soil Erosion and Carbon Dynamics. CRC Press, New York.

Nelson RE, Sommers LE (1982). Total Carbon, Organic Carbon and Organic Matter. In: Keeney DR, Baker DE, Miller RH, Ellis RJ, Rhoades JD (eds) Methods of Soil Analysis, part 2. Chemical and Microbiological Properties. Am. Soc. Agro. Soil Sci. Madison, Wisconsin, pp. 539-580.

Ryan J, Estefan G, Rashid A (2001). Soil and Plant Analysis Laboratory Manual (2nd eds) International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo.

Schimel DS, Parton WJ, Kittel TGF, Ojima DS, Cole CV (1990). Grassland biogeochemistry: links to atmospheric processes. Climatic Change, 17: 13-25.

Steenwerth KL, Jackson LE, Calderon FJ, Stromberg MR, Scow KM (2002). Soil microbial community composition and land use history in cultivated and grassland ecosystems of coastal California. Soil Biol. Biochem., 34: 1599-1611.

Stromberg MR, Griffin JR (1996). Long-term patterns in coastal California grasslands in relation to cultivation, gophers and grazing. Ecological Appl., 6: 1189-1211.

Titi AE (2003). Effects of Tillage on Invertebrates in Soil Ecosystem. In: Titi AE (eds) Soil Tillage in Agro- ecosystems. CRC Press, New York, pp. 261-297.

Vacca A, Loddo S, Erra G, Aru A (2000). Soil degradation in Sardinia (Italy) main factors and process. J. Options Mediterranean's (Italiy), A: 413-423.
USDA (2008). Agricultural Research Service, USDA: and Bureau of Land Management, USDI. http://soils.usda.gov/sqi.
Yan F L, Shi Z H,Li Z X, Cai C F (2008). Estimating interrill soil erosion from aggregate stability of Ultisols in subtropical China. Soil Tillage Res., 100 (2008) 34–41.
Youjun H, Qingkui W, Silong W, Xiaojun Y (2007). Characteristics of Carbon and Nitrogen of Soil Microbial Biomass and Their Relationships with Soil Nutrients in Cunninghamia lanceolata Plantations. Higher Education Press and Springer-Verlag.