A study of the effects of deforestation on soil organic matter properties in a semi-arid ecosystem (Central Iran)

J. Fallahzade[1*], M. A. Hajabbasi[2] and B. Khalili[2]
[1]Department of Soil Science, College of Agriculture, Islamic Azad university, Khorasgan branch, Isfahan 81595-158, Iran
[2]Department of Soil Science, College of Agriculture, Isfahan University of Technology, Isfahan 84156-83111, Iran

[*]Corresponding author: E-mail: jaber84023@yahoo.com, Tel +98 0913 254 3570

Abstract
In forest land of Central Iran, data regarding the labile pool of soil organic matter (especially carbohydrates) is scarce. A study was initiated in 2009 to evaluate the effects of deforestation on soils organic matter properties in Lordegan region of central Zagrous Mountain, Iran. Soil samples were collected from forest Oak (*Quercus brantii Lindl.*) and adjacent cultivated sites (snap bean (*Phaseolus vulgaris L.*) and tomato (*Lycopersicum esculentum Mill.*)). In this study, soil organic carbon (SOC), carbohydrate, and no-hydrolysis carbohydrate in both land uses were studied. The results showed that land use changes (i.e. conversion of forest to cultivated fields) resulted in significant decreases in concentration of SOC, carbohydrate, and no-hydrolysis carbohydrate. In addition, soil organic matter pools were greater in forest than in the cropland soils, reflecting a better soil quality and thus higher potential for increasing soil organic carbon sequestration in the forest lands.
Keywords: Land use change; deforestation; soil organic matter; carbohydrate.

1. INTRODUCTION

Soil organic matter (SOM) is a main sink for atmospheric CO_2 and other greenhouse gases [1]. Also, soil organic carbon (SOC) is an important source of inorganic nutrients for plant growth and subsequently in sustaining ecosystem productivity. Soil carbohydrates constitute a significant part of the labile pool of SOM and are most affected by land use changes [2].

Intensification and expansion of agricultural activities have led to soil degradation in most ecosystems, especially in arid and semi-arid ecosystems [3]. Land use changes, especially cultivation of forest lands, may instantly lower soil quality. Deforestation is an imaginable status of human activities in environments and ecosystems.

The forests of Iran cover approximately 12.5 million ha and constitute 7.5 % of the total area of the country. The Zagros forests, with an area of around 5 million hectares, account for almost 40% of the country’s forests. Zagros forests are one of the most important and sensitive ecosystems in Iran. The oak (Quercus brantii Lindl) forests of Zagros Mountain, Central Iran have been exposed to deforestation for the last four decades. Forest soils in this region are being seriously degraded and destructed due to extensive agricultural activities. More than 1.7 million ha of the Zagros forests have been deforested since 1962. Currently, Zagros forests are considered as degraded forests.

These changes (deforestation in Zagrous Mountain) have resulted in a great decline in the physical, chemical, and biological quality of soil resources in central Iran [3]. Several studies have produced consistent results on the effects of land use change (conversion of native forests to cultivation) on SOC and carbohydrate contents. For example, Spaccini et al. [2] in Ethiopian highlands and

Nigerian lowlands showed that SOC and carbohydrate content was higher in the forested than the cultivated soils. Ashagrie et al. [4] concluded that total amounts of SOC were significantly larger in the natural forest than in the cultivated soil in southeastern Ethiopia. Also, Nael et al. [5] in central Zagrous Iran reported that the amount of SOC was significantly higher in the forest land compared to the cultivated fields.

However, data regarding the labile pool of SOM (especially carbohydrates) in forest and cultivated soils in Central Iran is scarce. Thus, the main objective of this study was to analysis the effects of converting forest to cropland on soil carbohydrate fractions.

2. MATERIALS AND METHODS

2.1 Study Area

The studied area (forest and an adjacent cultivated sites) is located in Lordegan (31° 19′ N, 51° 10′ E), Zagros mountains, west central Iran (Figure 1), and at an elevation of around 2100 m above sea level, with an average annual rainfall of 500 mm and an average temperature of 15 °C.

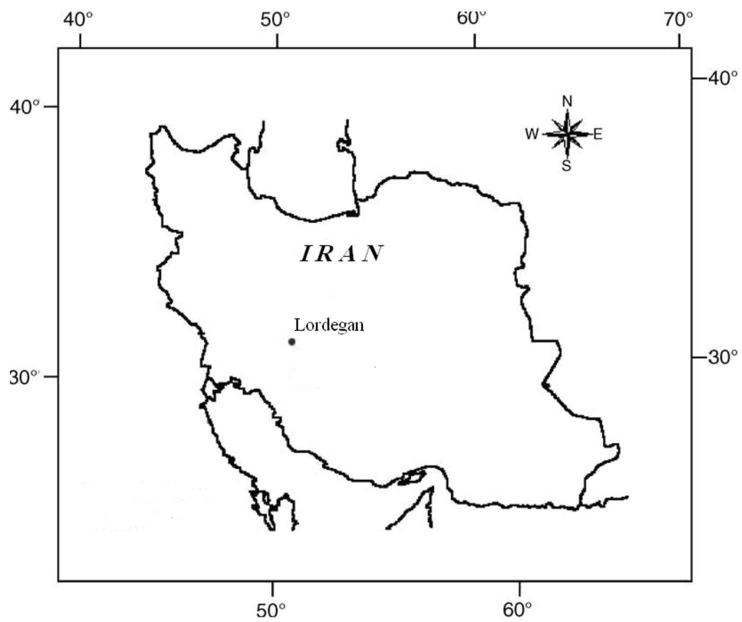

Figure 1. Location of the study area in west Central Iran.

Topographically, the selected sites are situated on a hills area along a high slope (30%) facing south. Forest lands were mainly covered with Oak (*Quercus brantii* Lindl.). The bouring cultivated site had been conventionally cultivated with vegetables including snap bean (*Phaseolus vulgaris* L.) and tomato (*Lycopersicum esculentum* Mill.) for the last 40 years.

2.2 Soil sampling and analysis

In October 2009 soil samples were collected from forest and an adjacent cultivated site to explore the effects of deforestation on soil organic matter properties. Soil samples were taken from 0–20 cm depth. Forest and cultivated sites were in the same topographic position and soil type. Soils of the area are calcareous with high calcium carbonate contents in the surface layer, which has developed in limestone. In the cultivated sites, mineral N (as urea) and P (as di-ammonium phosphate) fertilizers are usually applied to improve soil productivity. After harvest, the crop residues were burned or removed by farmers. Soil pH and electrical conductivity (EC) was measured in saturated extracts and SOC (the Walkley and Black method) was determined via procedures described in Baruah and Barthakur [6].

2.3 Measurement of carbohydrate

One gram of each soil was mixed with 10 ml of 0.25 or 0.5 M H_2SO_4 and shaken in a plane rotary shaker for 16 hour. The soil suspensions were centrifuged at 3000 rpm for 30 min. After centrifugation, 2 ml of supernatant solution was used to determine carbohydrate concentration using phenol–sulfuric acid method of Dubois et al. [7]. The absorbance was read in a spectrophotometer at 490 nm. The calibration curve was obtained using glucose standard.

2.4 Measurement of not-hydrolysis carbohydrate

Briefly, one gram of each soil was mixed with 10 ml of 0.5 M $(NH_4)_2SO_4$ and heated (85˚C) in oven for 16 h. The soil suspension were centrifuged at 3000 rpm for 30 min. The absorbance was read in a spectrophotometer at 490 nm.

2.5 Statistical analysis

The physical and chemical properties in the whole soils were repeated three times. The effect of deforestation on soil variables was determined by one-way analysis of variance (ANOVA). Mean values were separated by Duncan test. Differences in the measured soil properties as a result of deforestation were considered significant only when *p*-values were lower than 0.05, unless established otherwise. Statistical procedures were carried out using the software package SAS 9.1 for Windows.

3. RESULTS AND DISCUSSION

3.1 Basic soil properties

All soils were basic and there was no significant effect of cultivation on soil pH (data not shown). The soils are classified as Typic Calcixerolls and Typic Calcixerepts in forest and cultivated sites, respectively. Also, EC and textures of soils were similar between forest and cropland sites (data not shown).

3.2 The concentration of SOC

The concentrations of SOC were highest in soil samples of forest and lowest in the cultivated soils (Figure 2.a). At 0–20 cm depth, the concentrations of SOC in forest land were about four times higher than those of cultivated soils (Figure 2.a). The lower SOC concentrations in cultivated soils may partly be attributed to reduced plant residues input in the surface soil during land clearing, land leveling, and the removal of plant residues. Also, the reduction of SOC concentrations following deforestation can be attributed to exposure of organic matter to mineralization. Therefore in cultivated sites, crop residues during land preparation were burned. Burning of crop residues significantly reduces SOC in the upper few centimeters of soil. Hajabbasi et al. [3] reported lower (50%) organic matter and total nitrogen in cultivated soils than the adjacent forest in the upper 30 cm depth. Several other studies have also showed large losses of SOM in forest soils following cultivation [2,4,5,8].

3.3 The concentration of soil carbohydrate

Land use change had a significant impact on soil carbohydrate fractions. Carbohydrate had a broadly similar trend with land use to SOC. The contents of carbohydrate extracted by 0.25 and 0.50 *M* H_2SO_4 was significantly higher in forest (5.9 and 6.6 g/kg) compared to the cultivated (2.8 and 3.3 g/kg) soils (Figure 2.b). This could be due to a greater return of plant residues (especially leaf residues) and less soil disturbance in forest which led to a greater rate of carbohydrate in forest lands. Similar findings were reported by Spaccini et al. [2] found that a decline of carbohydrate concentration might have resulted from deforestation in Ethiopian and Nigerian. Bongiovanni et al. [8] also believe that the dilute acid extractable carbohydrate concentration in soil decreased 47% because of cultivation.

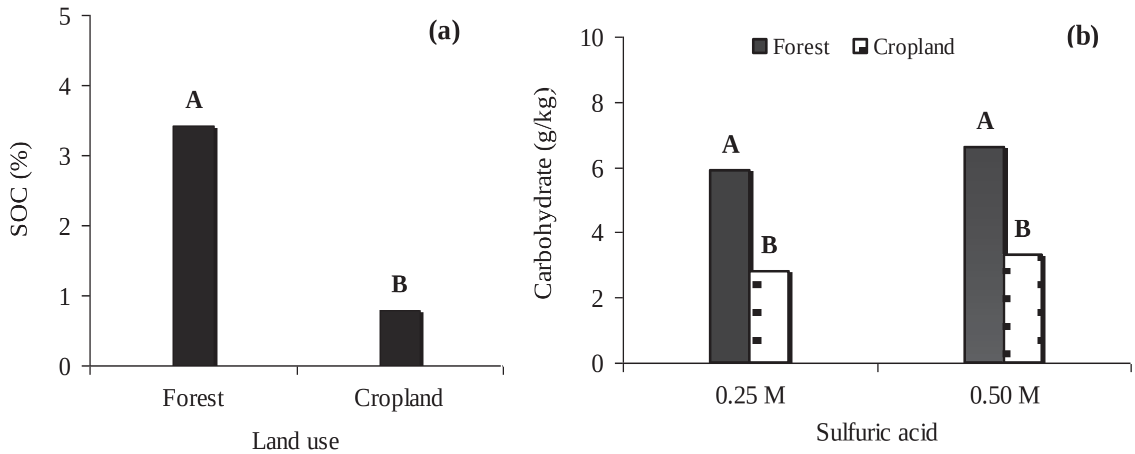

Figure 2. Concentrations of SOC (a) and carbohydrate (b) in forest and cultivated soils. Different letters within each characteristic, indicate statistically different values according to Duncan test ($P<0.05$, n = 3).

3.4 No-hydrolysis carbohydrate

Land use change from natural forests to croplands resulted in significant decreases in no-hydrolysis carbohydrate. The amount of no-hydrolysis carbohydrate was 5.0 (g/kg) for forest and 0.4 (g/kg) for cultivated soils (Figure 3.a). The ratio of no-hydrolysis carbohydrate to SOM of the land uses (forest and cropland) are shown in Figure 3.b. The ratio of no-hydrolysis carbohydrate to SOM in forest land was significantly higher than that in the cropland. Greater inputs of young and labile residues from Oak tree could be accounted for the higher no-hydrolysis carbohydrate and ratio of no-hydrolysis carbohydrate to SOM in forest land to cropland.

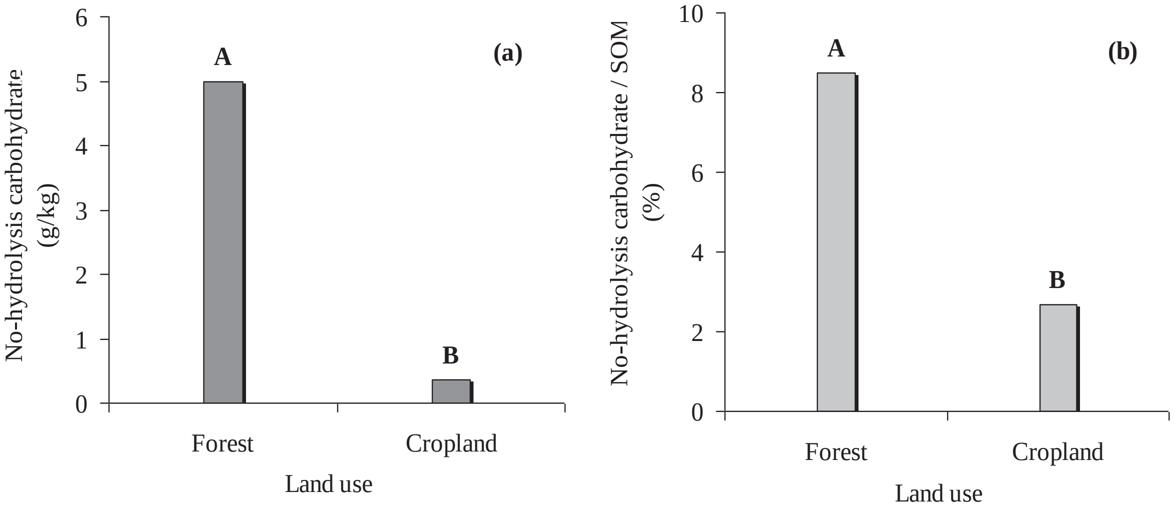

Figure 3. Concentrations of no-hydrolysis carbohydrate (a) and ratio of no-hydrolysis carbohydrate to SOM (b) in forest and cultivated soils. Different letters within each characteristic, indicate statistically different values according to Duncan test (P<0.05, n = 3).

4. CONCLUSIONS

Results of the current study show the negative influences that land use conversion from native forest to croplands might have on soil organic matter properties. The results showed that soil organic matter pools (SOC and carbohydrate) were greater in forest than in the cropland soils. The decreases in SOM content by cultivation were mainly related to lower carbon inputs from crop residues incorporated in the surface soil with rapid oxidation and decomposition of SOM in cultivated soil. In summary, the deforestation in this area could be a reduction of carbon sequestration potential in the soil, and thus enhancing CO_2 concentrations in the atmosphere and subsequently contribute to global warming.

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