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Soil Organic Carbon: A Key Factor of Sustainable Agriculture in Iran

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Abstract

This paper outlines general pictures of soil organic carbon (SOC) in Iran as a heart of sustainable soil fertility. Regarding this, SOC content in 61.6 percent of the agricultural soils of Iran are less than one percent. Declining trend of SOC has been shown in two regions with different climate. Causes which influence reducing SOC in Iran have been mentioned. Some positive signs towards soil organic carbon management including policy making and research results have been described. Finally, future research priorities in understanding the status and management of SOC have been proposed.

Keywords: SOC, Sustainability, Management, Research priority

Introduction

Soil organic carbon is a key factor in the sustainability of soil fertility and soil ecological services (Lal. 2013). SOC, as one of the major environmental issues and challenges on a global scale is also included in the United Nations Environment Program (Victoria et al. 2012). It is known that soil organic matter is effective on food production, nutrient and energy cycling, soil water storage, improving soil physical condition and erosion control, climate regulation, and soil biodiversity (Banwart, et al. 2015). Iran is located in the arid and semi-arid region of world with low organic carbon in soils. That's why management of organic carbon in soil is a key factor towards sustainable agriculture in the country. In this paper, we present a general picture of the situation and dynamics of SOC in Iran. The most important and effective methods for SOC management have been introduced and finally some research priorities listed.

Methodology

The situation of SOC was assessed in 23700 soil samples taken from agricultural lands of Iran during last three decades. The relation between climate condition and the amount of SOC in different agroechological zones of the country also has been analyzed. Moreover, it has been tried to examine the changes of SOC by comparing the data from different time periods. By Referring to research, the effects of different crop management on SOC content were shown. Finally, future research priorities in understanding the status and management of SOC were proposed.

Results

Organic carbon content in soils of Iran

Organic carbon content in 61.6 percent of the agricultural soils of Iran is less than one percent which suggests unsustainability of soil fertility (Balali, et al. 2014). SOC content in 21.6 percent of soil samples

was less than 0.5 percent, in 40.0 percent of soils between 0.5 to 1%, in 24.04 percent of the soils between 1 and 1.5% and in 14.0 percent of soil samples was more than 1.5 percent which is defined as optimum range (Figure 1).

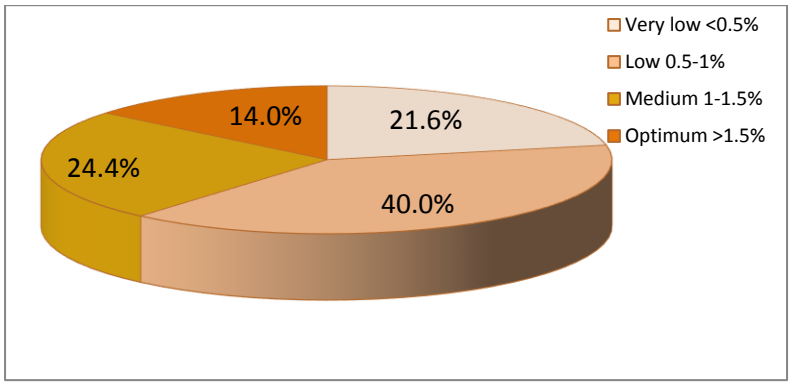

Figure 1. Range of organic carbon content in agricultural soils of Iran

Independent study conducted for monitoring soil quality with 3000 soil benchmarks (one sample for every 600 hectares) confirms these results. The results of this study showed that organic carbon in 68.7 percent of soil samples are less than one percent (sadat and Rezaei, 2014). Assessment of changes in SOC in different time series in Dezful region (semi-dry), south of Iran, represents the declining trend (table 1). This trend also observed in North of Iran (moist-subhumid to humid) which in 1960's average amount of SOC was 3.2 percent (Dewan and Famouri, 1964) which is reduced to 1.7 percent.

Table 1. Changes in SOC in Dezful, South of Iran.

The relative amounts of soil samples contained less than one percent of SOC (%)	Number of soil samples	Time period
79.5	150	1960's
68.3	100	1990's
88.0	200	2000's
100.0	120	2010-2014

Three sets of reasons influence reducing SOC in Iran. 1- Climatic condition. Organic carbon distribution in different agroecological zones of Iran and its compliance with the distribution of rainfall in these areas clearly prove the effects of climatic condition on the amount of organic carbon in soil (figure 2). With the exception of northern and some western regions of the country, there is not enough capacity to the accumulation of organic carbon in soil because of the dry and semi-dry condition. 2- Undeveloped soils (entisol, Inceptisol and Aridisol) and unsuitability of soil quality (shallow depth, salinity and alkalinity, water logging, low fertility of soils) affects the growth and development of plants and afterwards the low amount of SOC storage, 3-Improper soil management which will be explained in the next section (samavat, 2015).

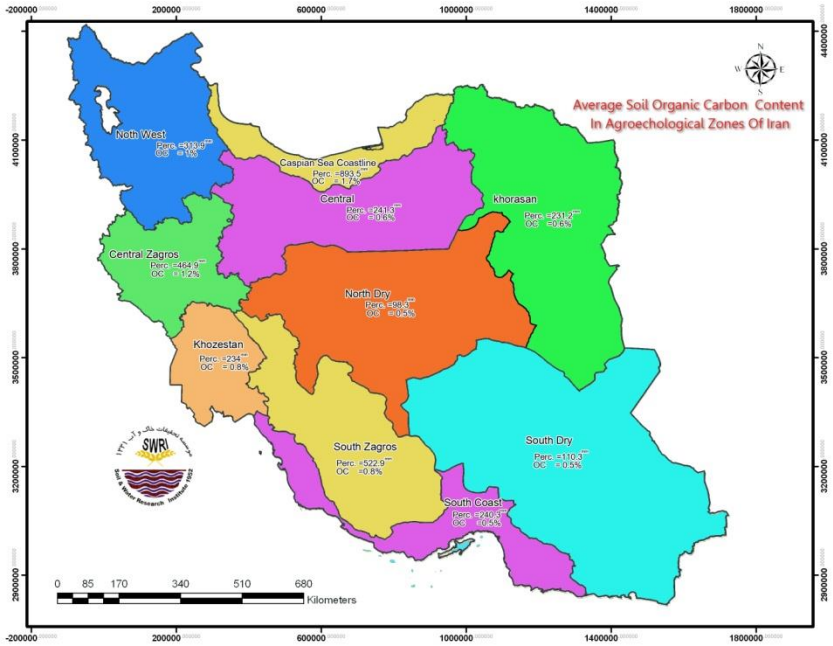

Figure 2. Average SOC in agroegological zones of Iran in relation to annual precipitation.

Management of SOC in Iran

Since land reforms of 1960's and change of agricultural system towards modernization in spite of increase of production, the downward trend of SOC has been started. Much of this decline in SOC associated with the use of chemical fertilizers and without any application of organic fertilizers in crop production, burning crop residue and inappropriate crop rotation and cropping system (e.g. monoculture). On the other hand, in the arid climate of Iran, increasing soil tillage acts as a reducing agent for SOC. Land use change from forest or pasture to agriculture have been also reduced OC storage in soils. Change of rangeland to dry farming in the western regions of Iran led to 23 to 58 percent drop in SOC content (Joneidi, et al. 2014).

However, there are some positive signs towards soil organic carbon management in a recent decade. Establishment of "High council for development of biological materials and balanced fertilization and pesticide application" in 1995 helped the development of research on soil organic carbon. On average, 286 kg increase in wheat grain yield per hectare has been reported for 1 gr increase of carbon per kilogram of soil (keshavarz, 2013). Samavat (2016) showed that integrated use of chemical and organic fertilizers significantly impact the performance of crops in wheat-corn rotation, the stability of soil aggregates in water, the amount of available water, the efficiency of nutrient uptake and the activity of soil microorganism. These show the importance of soil organic carbon management in sustainability of crop production. Research results have shown of SOC in agricultural lands of Iran.

Organic fertilizers application is one of the most important activities in increasing SOC. Moshiri (2016) showed that the positive effects of animal manure and urban waste compost application in increase the SOC observed up to 2 years in wheat-corn production system. Nevertheless, due to the limits of available organic fertilizers in Iran (almost 9 Mt) and extend of agricultural lands (16000000 ha), it is not possible to increase SOC in a large-scale only with organic fertilizer application. Hence, by using appropriate agricultural practices such as crop rotation, residue retention on soil surface instead of burning, development of conservation tillage there is a hope to maintain and or increase the SOC in Iran. Mirzavand (2015) by establishment of conservation agriculture practice in a long term experiment

showed that after 4 years, organic carbon content in soil surface (0-20 cm) was increased by 15 percent using no-tile management in comparison to minimum and conventional tillage.

Research priorities

The significant increase or maintaining optimum level of organic carbon in soils of Iran is not simple. It requires sustained effort that includes two general approaches adding organic matter to the soil and reduces the carbon loss. Due to the soil condition and climate change, it seems the first step must focus on those operations that lead to reduced loss of organic carbon from soils and pay attention to increase the SOC. Thus, future studies should be designed and implemented in response to the following questions

- What is the amount of SOC in the soil profile under different land uses and climatic conditions?
- How is the trend of SOC changes in different regions and climatic conditions?
- What is the carbon storage capacity of soils in Iran?
- To achieve the sustainable soil fertility and good soil ecological services, what is the optimum and desirable amount of organic carbon in the soil?
- What is the effect of soil properties (physical, chemical and biological) on SOC storage capacity?
- What is the impact of different crop management on SOC storage and sequestration?
- What is the effect of organic fertilizer and organic soil conditioner on SOC storage and carbon sequestration?

Conclusions

Dry and semi-dry climatic condition, existence of several limitations in soils for plant growth, changes in land use, improper soil and crop management practices, the lack of widespread use of organic fertilizers caused the low content of organic carbon in soils of Iran. Research studies have shown that the amount of organic carbon in soils of Iran is declining. In order to maintain or increase SOC, at first, the soil carbon reducing agents must be controlled (reduced tillage) and then use of organic fertilizers (integrated management of soil fertility) and correcting agricultural operation (development of conservation agriculture) must be considered.

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