Spatial distribution of organic carbon in dryland soils: case of Tunisian continental oasis Guettaya-Kebili

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Abstract

This work presents a study of the spatial distribution of organic carbon in soils of a continental oasis Guettaya in the region of Kebili, so that we have an idea about the contribution of arid soils in carbon sequestration. 80 samples were collected from six stations according to a toposequence. Sampling concerned the first 30 centimeters of soil. Physicochemical analysis have identified the main characteristics of the soil. Soil organic carbon rate varies from one station to another, in some stations it exceeds the rate of 3%, and generally it is abundant in surface layer compared with the underlying layers. Regarding the stock of organic carbon, at a depth of 30 cm, the highest stock is 57.7 t/ha and the lowest is 28.7 t/ha, and soil salinity varies from 2 g/l to 12 g/l. We found that soil organic carbon stock are influenced by soil salinity, bulk density, and soil texture. The soil organic carbon helps to maintain the balance of the oases ecosystem. In this oasis, the org carbon storage exists with relatively high levels, and appears to be a carbon sink to high potential in comparison with what exists outside the oasis.

Keywords: Soil organic carbon stock, oasis dryland soils, soil salinity, Tunisia.

Introduction, scope and main objectives

Dryland soils are low in organic carbon (<1%) due to the low productivity of the agroecosystems they support (Feng and Fu., 2013; Seager et al., 2007). Nevertheless, the size of the areas concerned means that the organic carbon stock in arid and semi-arid regions is far from being negligible with close to 750 Gt of carbon (Bernoux. 2011). Depending on the classification criteria, dry regions represent less than 30% of the total organic carbon stocks in the soil.

In south of Tunisia over half of the rural population is directly dependent on locally grown crops and data palm production. Reduction in soil fertility depletion has been highlighted as the single most important constraint to food security in South Tunisia (Mlih et al., 2016). Maintaining organic carbon (OC) and total nitrogen (TN) status; hence also soil fertility, is therefore critical in the food security of this climate vulnerable region. Date palm production is the only agriculture source of employment and income in southern Tunisia, it plays social and economic important role with 30% of world production and 70% of total Tunisian date production. However, these arid regions are characterized by a low SOM content not exceeding 0.8%, very high soil salinity and irrigation water with a more or less salty, which leads to degradation of soil quality and decreased fertility. The objective of this study is to estimate the organic carbon stock in the first 30 centimeters deep in the aridisols of the Guettaya oasis in southern Tunisia and to see the behavior of the stock as a function of salinity.

Methodology

The study area

The Guettaya oasis is a modern continental oasis located in the south of Tunisia. It is administratively attached to Kebili governorate. It is located between 8.27° to 8.29° N latitude and 33.24° to 33.26° E longitude. It has a dry hot desert climate, and the annual precipitation is irregular and less than 90 mm.

Samplings and analysis

Samples was conducted following a linear path about 1 km, the starting point was the center of the oasis on the way to the Chott. 5 profiles have been carried out every 200 meters to 1 km inside the oasis (P1, P2, P3, P4 and P5), and P6 the outside profile of the oasis in the Chott. Sampling concerned the first 30 cm and are taken according to well-defined depths: 0-5; 5-15 and 15-30cm. For each sample, we performed three measurements

Procedure for determining the individual SOC stocks

To estimate SOC stocks, requires knowledge of the vertical distribution of OC in profiles. The way of calculating SOC stocks for a given depth consists of summing SOC Stocks by layer determined as a product of D_b, OC concentration, and layer thickness. For an individual profile with n layers, we estimated the organic carbon stock by the following equation:

$$SOCs = \sum_{i=1}^{n} D\mathrm{b}i \times OCi \times Di$$

Where SOCs is the soil organic carbon stock ($t.ha^{-1}$), D_{bi} is the bulk density ($Mg.m^{-3}$) of layer i, OC_i is the proportion of organic carbon ($g\ C.g^{-1}$) in layer i, D_i is the thickness of this layer

Results

Analyses of the size usually indicates that soil texture is sandy loam. The EC values range between 3.2 and 17.1 mmoh/cm. And the values of salinity is between 2.3 and 17.2g/l in the oasis. Depending on the values of the salinity, it is deduced that the salinity peaked at P6 (up to 145.84 g/l) and P5 (salinity > 12 g/l), where the texture is smooth.

Table 1: The different analyzes carried out for the six profiles

Profile	Depth cm	Granulométry %					pH	EC mmho/cm	$CaCO_3$ %	Salinity g/l
		CS	FS	CS	FS	C				
P1	0-5	2	45	0	33	16	7.2	9.1	3	7.28
	5-15	2	43	0	40	12	7.7	4.0	3	2.8
	15-30	2	67	1	20	7	8.0	3.4	7	2.38
P2	0-5	13	42	0	34	8	7.7	8.2	3	6.56
	5-15	15	47	0	28	7	8.1	3.2	2	2.24
	15-30	15	48	0	25	8	7.9	5.6	2	3.92
P3	0-5	13	30	0	37	16	7.3	17.1	4	13.68
	5-15	15	42	0	27	12	7.5	7.3	7	5.11
	15-30	31	38	1	23	3	7.7	6.7	7	4.69
P4	0-5	22	44	1	26	4	6.2	16.6	5	13.28
	5-15	27	35	1	26	8	6.2	4.0	4	2.8
	15-30	22	41	0	27	6	6.6	4.2	3	2.94
P5	0-5	19	24	0	40	15	6.7	34.0	4	27.2
	5-15	26	23	0	31	16	6.7	15.4	2	12.32
	15-30	21	36	1	35	5	6.6	15.4	2	12.32
P6	0-5	NM	NM	NM	NM	NM	6.9	182.3	3	145.84
	5-15	NM	NM	NM	NM	NM	7.2	139.3	2	111.36
	15-30	NM	NM	NM	NM	NM	7.1	6.5	5	4.55

CS: Coarse sand; FS: Fine sand; CS: Coarse silt; FS: Fine silt; C: Clay; NM: Not measured

Although the levels of other stations, the values of the salinity range between 2.38 and 13.68 g/l. These values indicate conditions at least saline, with a coarse texture. These results show the close relationship between salinity and soil texture. The pH is between 6.2 and 8.1. The soil is very rich in low $CaCO_3$ contents there and vary between 2 and 7%, table 1 summarizes the main results.

Spatial evolution of organic carbon

The three curves for each profile are the measurements of the three replications for P1 to P5, just one measure for P6.

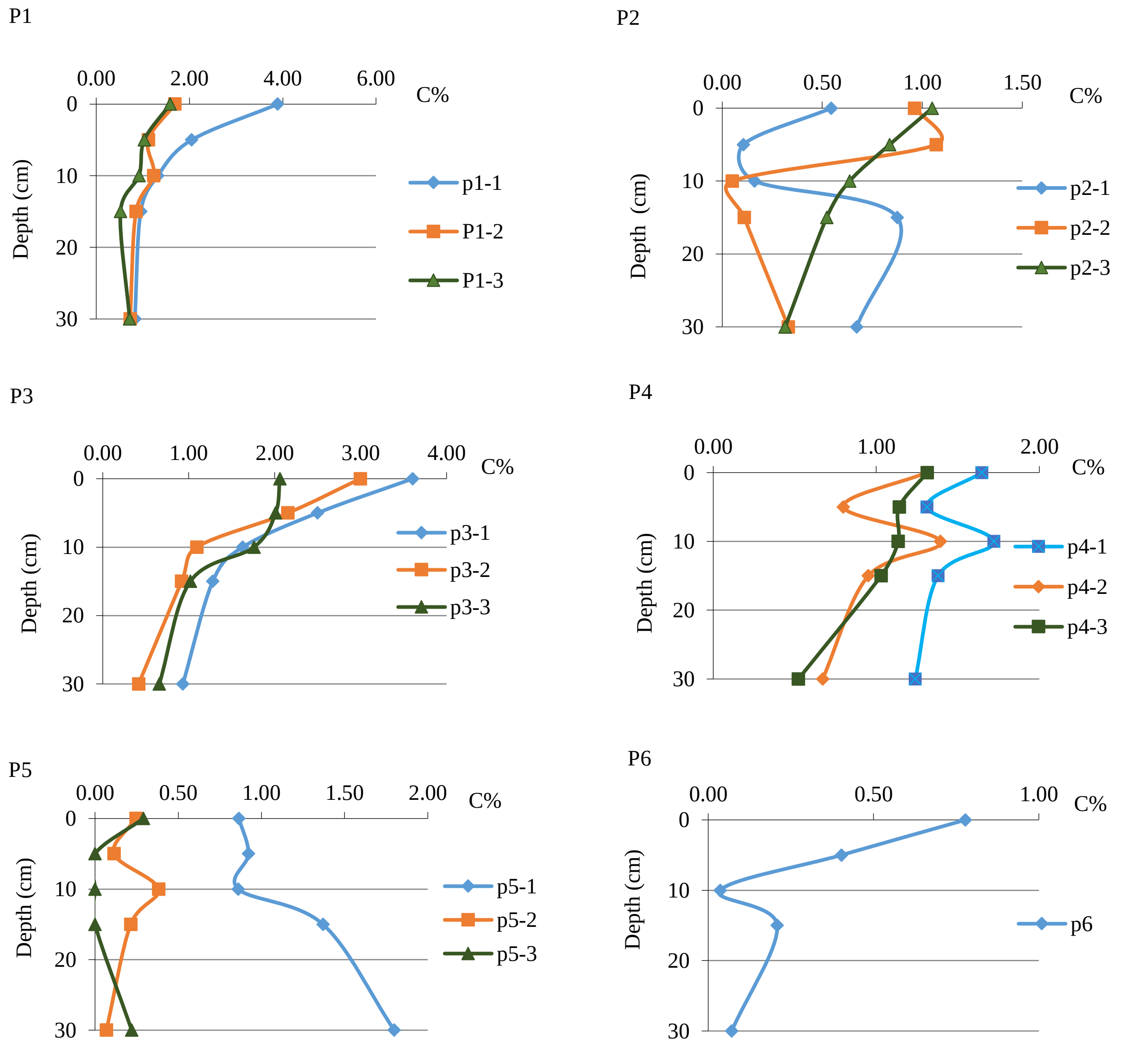
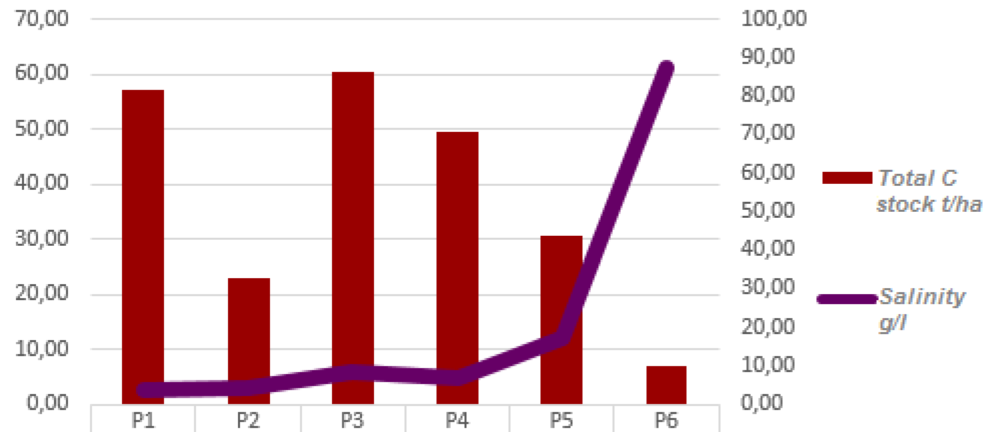


Fig. 1: The distribution of organic carbon in the six profiles

For P1, P3, P4 stations, P5, P6, the contents of org C are more abundant in the upper layer and they decrease with depth, except for the station P2, where the profile is in contrast to other stations. The rate of organic carbon is influenced by the physical properties of the soil; D_b and its texture. And it is higher in the surface layer (0-10cm). Based on the results of obtained D_b, we note that it is low on the surface, showing plenty of org C in this layer, which is characterized by a fine texture. In the underlying lower layer, which is characterized by a coarser texture relative to the surface layer, we notice low organic carbon relative to the surface layer. At P5, the profile adjacent to Chott, we recorded the lowest levels of organic carbon, this is explained by the very high salinity. In the different profiles, we note that the highest grades are at the level of the surface. We also note that the grades diminish as they approach the Chott.

Soil organic carbon stock

The histogram focused on Figure 2 shows the distribution of the carbon stock in the six profiles on the depth of 30 cm. At the same time, we have also shown the evolution of salinity. Despite the fact that these soils are desert, the stock is relatively high in all the profiles except profile P2 which is explained by a lack of organic addition by its farmer owner. For P6 it is a halomorphic soil in full Chott.



	P1	P2	P3	P4	P5	P6
total C stock t/ha	57,20	22,86	60,57	49,45	30,55	6,79
Salinity g/l	3,85	3,97	8,29	6,61	17,28	87,47

Fig. 2: The organic carbon stock and the evolution of salinity in the six profiles

At the oasis, the highest stock is 60.57 t/ha, the lowest stock is 22.86 t/ha. At the level of the Chott the stock is much less low it is of the order of 6.79 t/ha. The stock appears to be dependent on two variables, that of organic addition and soil salinity.

Discussion

The rate of organic carbon is influenced by the physical properties of the soil; bulk density (D_b) and its texture (Brahim et al., 2014; Liu et al., 2011; Gallali, 2004), and it is higher in the surface layer (0-10cm) and below (Zhang and Shao, 2014). Based on the results of obtained D_b, we note that it is low on the surface, showing plenty of organic carbon in this layer, which is characterized by a fine texture. The underlying layer is characterized by a coarser texture, we notice low organic carbon relative to the surface layer. Indeed, the decomposition of OM is important in soils with coarse texture (Pallo et al., 2009). Soil salinity reduces crop production, leading to the absence of litter, which reduces the input of organic matter (Setia et al., 2012). According to Kadri and Van Ranst (2002), texture evolves from a coarse upstream to downstream fine texture near Chott. More, salinity affects negatively on plants and therefore it tends to decrease the amount of litter resulting in the decrease in input organic carbon in soil (Setial et al., 2012). By consequences, the carbon stock is influenced by soil physical characteristics such as particle size and D_b (Zhang and Shao., 2014). At the oasis Guettaya, soil organic carbon stocks at the surface layers are very similar to stocks encountered in agricultural soils of the northern Tunisia (Brahim, 2011). As a result, arid and desert soils could be carbon sinks if properly maintained and could contribute to the reduction of atmospheric greenhouse gases (Li et al., 2013).

Conclusions

According to the obtained values of organic carbon, we recorded the highest values in the five profiles in the oasis, however, the nearest profile to the Chott have the very low organic carbon rate. As regards the carbon stock, we noticed that it varies from one station to another. The average stock at the oasis from the 5 profiles located at the level of the oasis is of the order of 44.12 t/ha. However, according to profile P6 at the periphery of the oasis, near the chot the stock decreases to 6 t/ha. This stock decreases with increasing salinity. The carbon stock is influenced by soil physical characteristics such as particle size and D_b. At the oasis, soil organic carbon stocks at the surface layers are very similar to stocks encountered in agricultural soils under semi-arid and subhumid climates.