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Research article

Soil organic matter management in coastal oasis

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Abstract

Farmer's management practices in arid areas can have profound effects on soil quality. The coastal oasis agrosystem is characterized by a higher density and diversity of vegetation cover that is linked to specific local cropping, land management, and higher soil moisture availability. In Chenini oasis, farmers make an annual addition of the organic matter in the soil. However, this practice is still traditional and usually done without a reasonable study. Thus a well-studied elaborate become a necessity to improve soil fertility in this conditions. This study is carried out in the oasis of Chenini (governorate of Gabes) to assess the effects of organic matter on the soil chemical properties of oasis and on their fertility. The results obtained from analysis revealed that the Chenini coastal oasis exhibited high soil organic carbon concentrations which reflected on the abundance of macro and micro nutrients.

Key words: Costal oasis, degradation, organic matter, Tunisia.

1. Introduction

In dry lands most of agricultural soils have low fertility and low nutrient reserves (Lal, 2004). There is a strong link between the soil quality and the soil fertility, and the depletion of the latter leads to soil degradation and vice versa (Lal, 2003). Apart from water scarcity, soil salinity, wind and water erosion, and extreme temperatures, the depletion of the soil fertility in drylands of the middle east and north Africa (MENA) region can be also accentuated by loss of organic matter (OM) as a result of soil mismanagement practices (Kassam et al., 2012), involving decrease in biomass production through clearing the land for planting or by overgrazing and thus disappearance of litter layer (Dalal et al., 2005). Decrease in soil fertility could also results from burning or removal of crop residues for use as animal feed and thus diminishes the amount of OM returned to the soil (Smith et al., 1992). Increase decomposition rate by tillage practices that enhance the aeration of the soil, which in turn accelerates the C cycle. Ploughing under dry conditions leaves no residues on the surface and exacerbates the grinding of the soil, causing the soil surface to crust more easily, leading to greater water runoff and erosion (Six et al., 1999). Vegetation cover is one of the key factors influencing soil quality. This is due to the positive feedback due to the OM contribution by means of the litter. Also, vegetation enhances rainwater infiltration and favors a less contrasted microclimate beneath plants due to the shadow. These conditions should generate more active fauna and flora communities (Cerda, 1998). In many management options such as keeping grasses in the crop rotation, returning all crop residues to the fields, cultivating no more than necessary and adding organic materials are considered as important sources of plant nutrients and improvement of soil physical and chemical properties (Reeves, 1997). In soil under cultivation for long time like oasis agrosystem, soil fertility can be restored by recycling of OM and plant nutrients. However, rebuild of these components can be achieved through appropriate farming practices may take several years, especially in dryland areas where limited moisture reduces biomass production and soil biological activity (Dregne, 2002). Tunisian oases are the source of human cultural and ecological knowledge, and their expansion has been always conditioned by water availability (De Haas, 2001). Most of Tunisian oases are located in the south of the country, covering a total area of 40803 ha, Continental oases cover 33723 ha (83% of total oases) (Sghaier, 2010). Oases play an important role in the development of arid regions as a source of employment and income for the majority of population of southern Tunisia. They are the most productive agrosystem in these regions; providing high market value products especially dates.

Furthermore, oases sustain the towns and cities that have grown around them, not only by providing food for people and wildlife that rely on them, but also through maintaining the social, cultural and economic life of local communities (Koohafkan and Altieri, 2010).

Oases ecosystems in Tunisia support a wide range of agriculture along with dates. Fruit and citrus trees are cultivated at a secondary level with vegetables and other plants grown at ground level (Tengberg, 2012).

Gabès oasis is part of the ancient oasis of southern Tunisia, (Louhichi, 1999). According to (Floret and Pontanier, 1982), the soils of coastal oases are characterized by abaundant gypsum and limestone formations, a low organic matter content, and high levels of calcium salts and sodium chloride. Soils of oasis are characterized by two different ways of degradations, firstly by hydromorphy which is the temporary or permanent waterlogging of the soil. Secondly, in oasis, hydromorphy is often associated with halomorphism, being given that the irrigation water is salt.These two forms of oasis soil degradation are caused by the increase of the water table (GID 2000, Sarfahil 1988, Kadriet Vanranst 2002).

Combing sandy soil texture with saline water, Agriculture was negatively affected, indeed, plant growth and yield was decreasing (Sharma et al., 1990).

Problems of hydromorphy and salinity are gradually increased in the oasis of Gabes, their impacts are very harmful on the soil properties; which has become impermeable by declining the biological activity and the soil aeration. Consequently, an inhibition of root respiration and humus mineralization.

In addition, oasis soils are characterized by a low fertility, related particularly to the amount of nutrients available from organic and inorganic soil reserves.

In the oasis, continued soil exploitation, without restitution of losses, reduce its reserves and affects its fertlity (Skiredj, 2007) and considered as major cause of fertility degradation.

According to Tistal and Oades (1982), organic matter increased the cohesion of aggregates by fixing mineral particles on organic polymers. Thus, the reduction of the soil organic matter rate of the oasis constitutes a main factor which generates to the diminution of its fertility.

In Gabes oasis, farmers make an annual addition of the organic matter in the soil. However, this practice is still traditional and usually done without a reasonable study. Thus a well-studied elaborate become a necessity to improve soil fertility in this conditions. This study is carried out in the oasis of Chenini (governorate of Gabes) to assess the effects of organic matter on the soil chemical properties of oasis and on their fertility.

2. Material and methods

2.1. Field experiment

The study was conducted at Chenini coastal oasis in Gabes, Chenini oasis stretches along the coast of Gulf of Gabes (Latitude 33 ° 53 North; Longitude 10 ° 12) in the south east of the country situated in the south of Tunisia. Chenini oasis climate is Mediterranean dry, hot in summer and mild in winter. Rainfall is low and erratic with an annual average of 186 mm. Under the influence of Saharan winds, the summer temperature can reach 42.5 °C in August, and falls to reach 5 °C in winter in December and January. The winds blow between December and April are cold, dry and carrying sand. The soils of the oasis are gypsum calcareous, according to WRB classification; it can be classified as Gypsisol.

The plot randomized complete-block design with three replications was used in this study. Size was 12m long and 2 m wide.

Two treatments were used in this study, untreated soil (U) and amended soil (F) (90k of organic matter in each plot). Amendments were applied on May 2014 and the organic matter is mixed in the layer depth of 0-20cm.

2.2. Soil sampling and analysis

Soils samples were collected within each plot treatment at three depth increment (0–20, 20-40 and 40-60 cm depth). All samples were placed in plastic bags, labeled and taken to the laboratory. Soil from each replicate was air dried, sieved and stored for chemical analysis.

Soil was air-dried and sieved through a 2mm sieve (2 mm) for chemical analysis. Soil pH was measured in a deionised water suspension with a soil:solution ratio 1:2.5 (Blakemore et al., 1987). The Total nitrogen N was determined by by Kjeldahl digestion–distillation method (Nelson and Sommers, 1973), Available P was extracted with Olsen reagent [0.5 M NaHCO

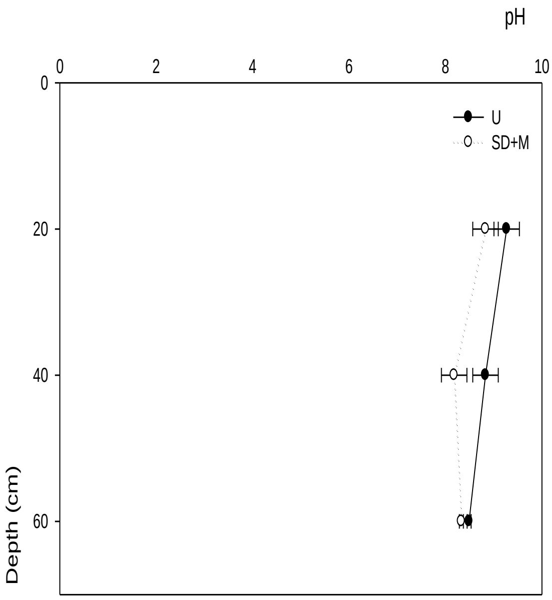

Fig. 1: Effect of amendment in pH

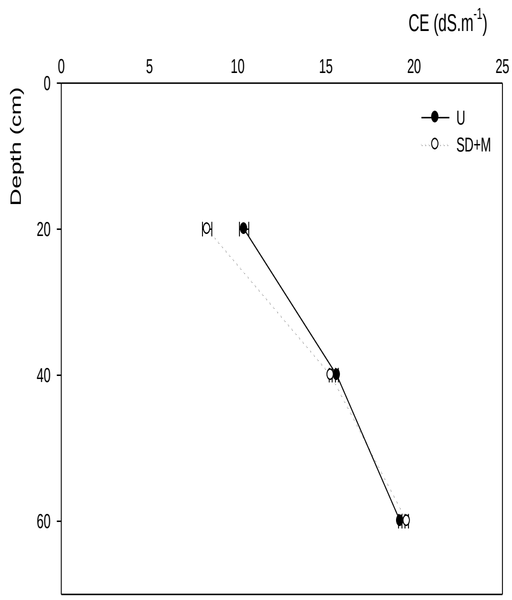

Fig. 2: Effect of amendment in EC

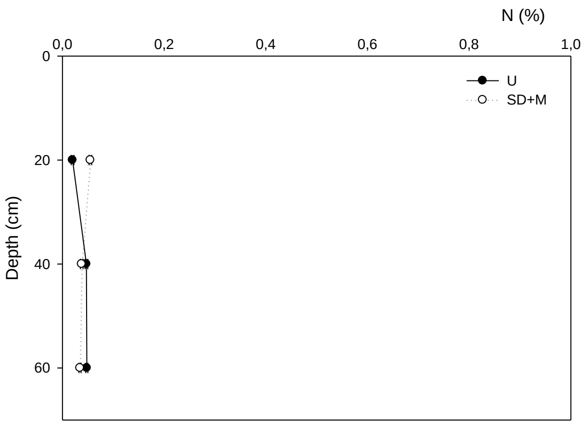

Fig. 3: Effect of organic amendment in soil Nitrogen

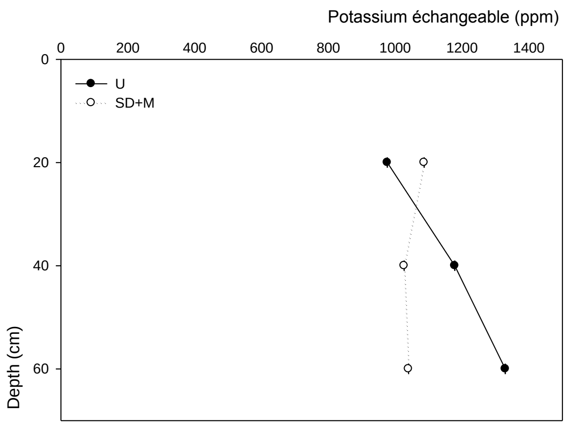

Fig. 4: Effect of organic amendment in soil Potassium

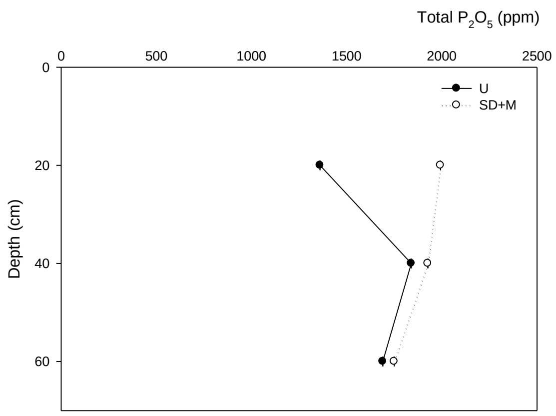

Fig. 5: Effect of organic amendment in soil Potassium

(pH 8.5)] at soil-extractant ratio of 1:20, shaken for 30 min and quantified by molybdenum–blue colorimetry (Olsen et al., 1954). Available K was extracted with neutral normal ammonium acetate (pH 7.0), shaken for 25 min and measured by flame photometry (Hanway and Heidel, 1952).

2.3. Data analysis

Data were subjected to statistical analysis with software SPSS statistical software package version 16 (SPSS Inc., 2010). Two factor ANOVA was performed to determine the effect of treatment, depth and their interactions on soil chemical variables. Means were compared by Duncan’s multiple range test (DMRT) at 5% significance level.

3. Results and discussion

3.1. Changes of soil pH and CE with treatment and different depth

Results showed a significant effect ($P < 0.05$) of organic amendment on pH with decreases for amendment treatment compared to untreated (U) under 0-20 and 20-40 cm. In addition, the rate of pH varied from 9.27 for control soil to 8.83 for amendment one (Figures 1, 2). Nevertheless, it still non-significant ($P > 0.05$) under the deep layer (40-60 cm). The pH results were predictable as they attributed to the highly salt contents encrusted in soil layers stem from the gypsum crust, irrigation with saline water and rising of the underground watertable (Boulbaba et al., 2012). In Chenini oasis for example, salt stress is exacerbated with the sea level incursion temporarily emerged the oasis. In this context, Estiven (2000), showed that oasis soils of Gabes were characterized by two fundamental constituents, the gypsum and calcareous with (20-30 % and 5-20%) respectively.

3.2. Change of soil total Nitrogen

The accumulation of nitrate in the upper soil layer might be affected by higher N contents in this layer (Sylvester-Bradley et al., 1988). The soil nitrate levels can also be increased through a rapid nitrification in well-aerated soils and warm environment with a pH of 6 to 8. However, the quick change in nitrate accumulation in both oases might be due to many processes such as uptake by plants and microorganisms, leaching and denitrification driven by water logging phenomena (Garwood and Ryden, 1986). Transport of nutrient by wind and water might be also an important factor in disrupt nutrient cycling in the absence of vegetation (Alfaro and Gomes, 2001; Okin et al., 2001; Schlesinger et al., 1990). Wind blowing southern Tunisia is observed to govern the movement of mineral dust aerosols and contribute severely to soil erosion (Sghaier and Picouet, 2000) (Figure 3).

3.3. The variability of potassium by adding organic matter

For the both, the control and manure-amended soils, the availability of potassium levels were high under the three depths. Therefore, and because of this sufficient amount in oasis soils, their potassium amendment is not necessary.

Under 0-20 cm, the manure addition increased the potassium contents. Its accomulation might be attributed to the abundance of SOM in the surface layers (Meek et al., 1982) and its levels can be decreased by crop removal or by lost in runoff, leaching or erosion (Kayser and Isselstein, 2005). This is in agrrement with Kharbech 2005 who found that the input of manure improved potassium content in soil (Figure 4).

3.4. The availability of phosphorus

Result showed that the soil phosphorus content was significantly ($p<0.05$) affected by organic amendment. In the top 0–20 and 20-40 cm soil layer, we enregistred 1993 and 1360 ppm for amended and control soils respectively. The accumulation of P in upper soil layers could be attributed to the accumulation of SOM or to chemical fertilization (McGill and Cole, 1981). (Figure 5). However, its reduction might be a result of plant uptake or leaching through the soil (Brady and Weil, 2010). Furthermore, P in soils is associated more with fine particles than coarse particles, thus its loss might be easier when soil erosion occurs (Sharpley et al., 1996).

The bioavailability of P in all study soils could be affected by soil alkalinity. Since P is strongly tied to soil pH, and the formation of iron and aluminum phosphate minerals results in the reduced solubility of P in strongly acidic soil, though, this solubility declines as the pH increases due to the reaction of P in alkaline soil with calcium (Bertrand et al., 2003).

4. Conclusion

The analyses of different chemical soil properties for oasis agrosystem soils revealed a significant variance among them. The high concentration of SOC and other nutrients in Chenini coastal oasis demonstrates the abundance of SOM in this oasis which reflects in turn the availability of other essential macro and micro nutrients. These findings indicate that the addition of organic matter could decrease pH and Ec of oasis soils. In fact the amount used in this experimentation is similar to applied by farmers in this region. It improved the fertility of soil by increased the nitrogen, phosphorus and potassium soil stocks. This justified the importance of organic ameneded applied since several years to improve the fertility of oasis soils.It remains to adjust the amount of optimal manure depending on the state of soil degradation and the crop system practiced.

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