Journal of Research in Environmental and Earth Sciences, 09 (2020) 252-256
Print ISSN: 2356-5799
Online ISSN: 2356-5802

www.knowledgejournals.com

Research article

Effect of sand and organic amendment on soil propriety of degraded oasis system on South Tunisia

Zied Zriba [a], Nissaf Karbout [a,*], Latifa Dhaouidi[b], Habib Bousnina [a], Mohamed Moussa[a]

[a] *Institute of Arid Regions, Djorf km 22 Mednine, Tunisia*
[b] *Regional Center for Research in Oasian Agriculture, Km1 route de Tozeur CP: 2260 Deguache-Tunisia*
** Corresponding author. Tel.: +216 97392383, E-mail address: nissaf.karbout@yahoo.fr*

Article history:
Received 23 May 2020; Received in revised form 15 August 2020.
Accepted 22 August 2020; Available online 1st September 2020.

Abstract
This work was designed to study the effect of traditional farmer's practices by the addition of gypsum sand dune (GS) with farm manure (FM) on the physical and chemical characteristics of oasis soils in Nefzaoua region in south Tunisia. This work was conducted in two oasis that have two different altitudes (Negga oasis and Zaafrane oasis), the results showed that the application of traditional farmers' practices improves soil fertility with the enhance of soil organic matter to attend 0.78% in amended soil. Amelioration of soil physical characteristics by the improve of soil porosity and water conductivity (Ks) to achieve12.44 ±0.42 cm/h in treated soil.

Key words: Oasis soil, Sand amendment, Organic amendment, Physico-chemical properties, Tunisia.

1. Introduction

Globally, phylogenetic resources have suffered from severe erosion, which has caused a decrease in biodiversity (Bouajila et al., 2016). This situation is caused mainly by the industrial revolution and changes in agricultural practices (Argueta, 2016) which have resulted in an intensification of several agricultural lands and their productions.

Actually, the oases system has started to lose its performance (CNEA, 2008) due to the manifestation of various degradation processes (Bousnina, 2004).

In Tunisia, the oases system constitutes a diversified production system (Nasr, 2005) and considerable genetic wealth. The date palm production is the principal production system. However, the environment constraints (salinity, hydromorphy, organic matter deficiency...) in the one hand and the water scarcity on the other hand this make the oasis system in very fragile equilibrium (Ghazouani, 2009). In addition, changes in socio-economic conditions in the region have affected the specific and varietal structure of these agrosystems to meet business requirements. To cope with these different forms of soil degradation and restore productivity, oasis farmers resort to traditional practices with the use of with sandy materials with farm manure to improve soil fertility. The aims of this work are to study the effects of physical and chemical characteristics of two oasis soil after application of traditional farmer's practices.

2. Materials and methods

2.1. Study area

Samples were collected from two traditional oases in the southern Tunisian from the region of Nefzoaua and Negga characterized by a difference of topography (Fig1).

The experimental design was a randomized block with four treatments; the area of an experimental unit is 16 m² (4 m long × 4 m wide). The four treatments were gypsum sandy soil + farm manure (GS + FM) applied in two oases and compared with untreated soil (U), this treatment was applied in April 2018. Farm manure (FM) is the same product traditionally used by goats and sheep producers, characterized with a slightly acidic pH (6.4), an organic carbon content of 471.23 g kg^{-1}; each repetition received 24 kg of manure, which equates to 15 t. ha^{-1}. Climatic data indicated that the site had an average annual rainfall of 40 mm, an average maximum temperature of 46.6 °C, an average minimum temperature of 1.9 °C and an annual potential evapotranspiration of more than 2000 mm / year. The wind current of the sirocco is strong (120 days) in summer, carrying large amounts of sand and dust.

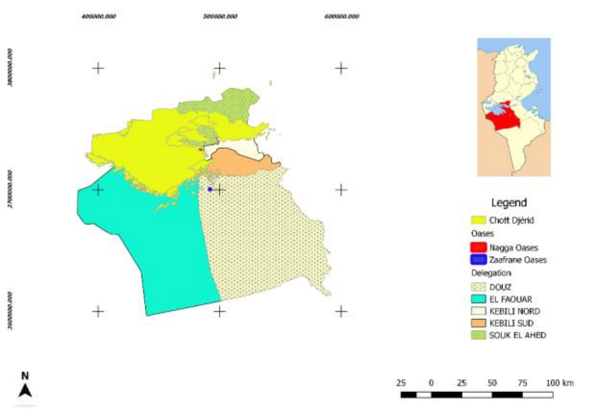


Fig. 1. Location of the Negga and Zaafrane oasis in Nefzaoua region

2.2. Sampling and preparation of soil samples

Samples were collected in three repetitions from three layers (0-20cm; 20-40cm and 40-60cm). The samples were collected at four different times: (i) directly after amendment on April 4th 2018 (t = 0), (ii) on June 3rd 2018 (t = 60 days), (iii) on August 2nd 2018 (t = 120 days) (iv) and finally on October 2nd, 2018 (t = 180 days). All samples were placed in plastic bags, labeled and sent to the laboratory. The soil of each replicate was air dried, sieved and stored for chemical and physical analysis.

2.3. Chemical and physical analysis

The soil organic matter (OC) in soil samples was oxidized with $K_2Cr_2O_7$ in concentrate sulphuric acid for 30 min followed by titration of the excess of $K_2Cr_2O_7$ with ferrous-ammonium sulphate. Nitrogen (N) in the digest was determined by Kjeldahl distillation and titration method (Bremner et Mulvaney, 1982).

The phosphorus determination is carried out by Jenway spectrophotometer at a wavelength of 660 nm. Phosphorus is calculated according to the following relation (equation 1):

$$P\ (ppm) = (C \times 10) / PE \qquad (1)$$

With:

C: read concentration of phosphorus in ppm

PE: soil test sample in g.

Soil BD was determined with stainless steel cylinder 5 cm in diameter and 5 cm in height and calculated from the weight of oven-dried soil at 105 °C and using (equation 2):

$$(BD) = W1 - W2/V \qquad (2)$$

Where BD indicates the soil bulk density (g. cm^{-1}), W1 is the weight of soil after drying in an oven and plus the weight of the stainless steel cylinder (g), W2 is the weight of the stainless steel cylinder (g), and V is the volume (cm^3) of the stainless steel cylinder.

The total porosity of the soil was calculated from the values of the dry bulk density and particle density using the following equation (3) (Aikins and Afuakwa 2012) :

$$\text{Total Porosity } (P\%) = 1 - (BD/PD) \times 100 \qquad (3)$$

BD = Bulk density

PD = Particle density

The saturated hydraulic conductivity, K_s, was estimated independently on the same samples using the constant head method.

2.4. Statistical analysis

SPSS 20 software was used for the meta-analysis described above to assess the response of the SOC concentration and TN concentration and Stock to different amendment, soil depth, and experimental duration.

3. Results and discussion

3.1. Effect of sand amendment organic amendment in chemical characteristics

From the examination of Figure 2, it appears that the sandy amendment is accompanied by an increase in the organic matter contents in the horizon 0-20 cm of the amended oasis compared to the untreated soil. This effect confirms that the sandy amendment is always accompanied by an organic amendment. Indeed, Mlih et al., (2016) showed that Nefzaoua soils are characterized by a low content of organic matter which requires an additional contribution to correct these soils. In Negga oases (Figure 2), the organic matter (OM) contents of the amended layer (0-20cm) and (0-40cm) are respectively 0.78% and 0.42% compared to 0.46% and 0.40% respectively in untreated soil in the same depth’s.

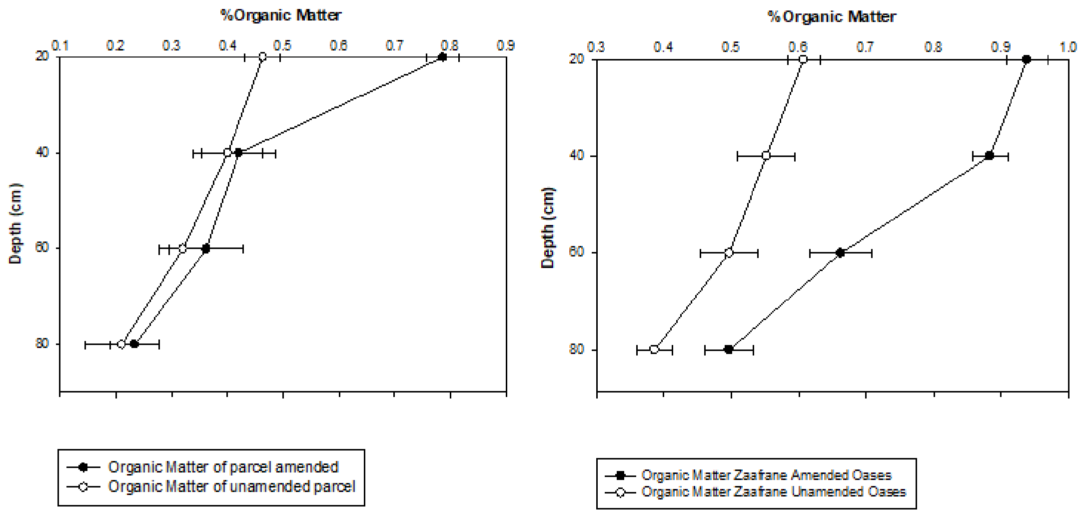


Fig. 2. The organic matter content in soils for the oases of Negga (1) and Zaafrane (2).

In Zaafrane Oasis (Figure 2), the organic matter (OM) contents of the amended layer (0-20cm) and (0-40cm) are respectively 0.93% and 0.88% compared to 0.60% and 0.55% respectively in the same layer's in the untreated soil.

Soil organic matter content in amended oasis soil is higher than those in untreated soil. This is due to decomposition and humification of manure brought with the spreading of sand as farmers use well-defined quantities of manure mixed with sand in the sand-spreading technique to better enrich and improve the fertility of the soil ground. The inputs of organic matter could contribute to stabilize the soil structure and limit the risks of degradation (Annbi, 2005).

The amount of organic matter present in a soil can have significant advantages over the water supply of the cultivated plants. Indeed, the presence of organic matter in the surface horizon increases the macroporosity, promotes infiltration and increases the rate of re-moistening of the soil, especially in late summer and autumn. Application of manure and other organic manures play an irreplaceable role during humification, the formation of stable humus fractions and in fertilization management (Simanskýa, 2019).

The results of Tong and al., (2014) indicated that application of manure caused the highest increase rate of total SOC in comparison with mineral fertilizers. Application of manures with mineral fertilizers can help achieve better soil quality (Zhang et al., 2012).

Table1 showed that for the amended soil in the Zaafrane oases, the average of total nitrogen content is 0.23 % in the 0-20 cm layer. This content decreases in the underlying layers to reach a value of 0.09 % in (60-80 cm) of depth.

Table 1. Total Nitrogen in Nagga and Zaafrane oasis

Oases	Depth (cm)	Amended soil	Untreated soil
Negga	0-20	0.13 ±0.020	0.031±0.004
	20-40	0.07±0.008	0.013±0.001
	40-60	0.03±0.007	0.005 ±0.004
	60-80	0.04±0.012	0.007±0.002
Zaafrane	0-20	0.2 ±0.019	0.081±0.001
	20-40	0.16±0.021	0.057±0.001
	40-60	0.07±0.02	0.042±0.002
	60-80	0.09±0.016	0.050±0.007

Whereas for untreated soil, the average of total nitrogen contents is 0.81 % in the surface layer (0-20 cm). At a depth of 80 cm, the average total nitrogen content is 0.05 ppm.

For Negga oases the average of total N content in 0-20 cm layer is 0.13 % to achieve 0.04 % in the upper layer (60-80cm).

Moreover, the results obtained for all the oases selected during this work, show that the nitrogen contents vary with the depth according to a decreasing gradient, but with a slight increase at the level of the fourth horizon, this is translated by the appreciable loss. Nitrogen in the upper layer and their accumulation in the deep horizon. This leaching phenomenon has been asserted, among others. Soils of Nefzaoua are classified as poorly evolved soils with coarse texture, because these soils cannot retain the chemical elements, these will be transported to groundwater through the macrospores. These results are confirmed by Yang and al., (2016). The soil phosphorus for the Negga and Zaafrane oases are shown in the figure3. For the amended soil in the Negga Oases, the average phosphorus content is 7.23 ppm in the 0 - 20cm layer.

This content decreases to achieve 2.65 ppm for the upper layer (60-80cm). However, for untreated soil (U), the average phosphorus content is 1.23 ppm and 0.63 ppm respectively in the superficial layer (0-20 cm) and (20-40cm). In the depth of (60-80 cm) the average phosphorus content is 0.45 ppm.

For the amended soil of Zaafrane oasis, the average phosphorus content is 12.63 ppm in the 0-20 cm horizon. This concentration decreases in the deeper layers to reach a value of 7.34 ppm for the depth of (60-80cm). However, for untreated soil, the average of phosphorus levels is 2.76 ppm and 2.42 ppm respectively in the superficial layer (0-20 cm) and (20-40cm).

The analyzes of the results of the average phosphorus contents for the soils of two oases show that these soils have a low phosphorus content (<20 ppm), this confirms that the organic and mineral amendment are introduced in an arbitrary and insufficient way and consequently these soils remain very deficient for all the oases of the Nefzaoua (Rawan, 2016). Phosphorus content changes with soil depth according to a decreasing gradient for amended plots and unamended plots (Jendoubi et al., 2014).

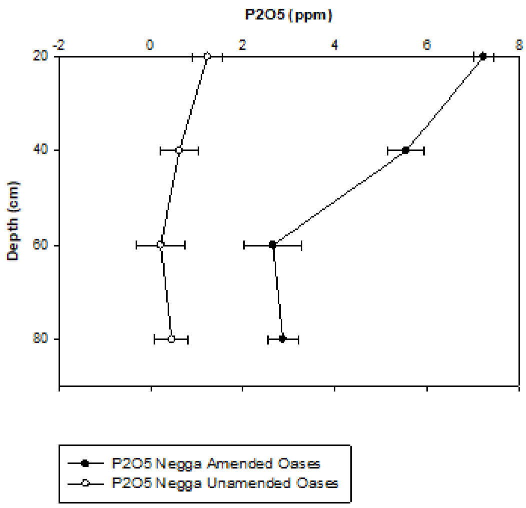
3.2. Effect of sand amendment/organic amendment in physical characteristics of oasis soil

After the addition of the sand/organic amendments, the table 2 showed the physical state of the soil in the function of the depth (Table2).

The analysis of the results shows that the amendment modified significantly ($p < 0.05$) the soil bulk density and the total porosity in the superficial layer (0-20 cm). In the Negga oases the bulk density decreases from 1.54 ± 0.45 g.cm^3 for the untreated soil to 1.35 ± 0.33 g.cm^3 for the amended soil. These decreases are accompanied with an increase in the total porosity of the soil to attend 41.88 ± 0.22% for the untreated soil to 49.05 ± 0.29% for the soil amended.

In the Zaafrane oases, the bulk density decreases from 1.41 ± 0.39 g.cm^3 in the untreated soil to 1.32 ± 0.31 g.cm^3 for the amended soil. This decrease in the bulk density accompanied with a decrease in the total soil porosity to achieve 46.79 ± 0.22% for the untreated soil to 50.18 ± 0.24% for the soil amended soil.

This change is due to a change in the soil structure in fact the addition of the sand-manure mixture used in the amendment favors a reduction of the bulk density and the porosity of the soils., This is confirmed by Guo et al., (2016), that organic materials have a low bulk density and a higher porosity, so mixing organic matter with mineral fractions in soils leads to a decrease in bulk density. Zebarth et al., (1999), have showed that the bulk density of the soil decreases with increasing carbon levels.



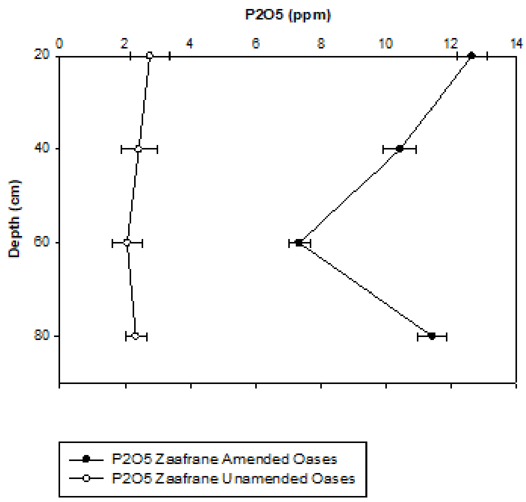


Fig. 3. The Phosphorus content in Negga (1) and Zaafrane (2) oases

This change in soil porosity enhances the hydraulic conductivity (Table 3) from 4.82 ±0.29cm h^{-1} and 8.87 ±0.34cm h^{-1} respectively for untreated soil in Negga and Zâafrane oases to 12.44±0.42 cm h^{-1} and 8.49 ±0.38 cm h^{-1} respectively in Negga and Zâafrane oases.

The sandy amendments have favored the increase of the permeability of the soil by the draining capacity of the sand used in amendment. The analysis of the results obtained shows that the surface permeability of the soil is higher than for the rest of the profile (Ibrahim et al., 2019). These high values of permeability provide good leaching of salts but a risk of wasting irrigation water (Bousnina, 1993). This classifies soils of different plots in the range of permeable to very permeable soils (Bousnina, 2004).

Table.2. Bulk density (BD) and soil porosity in Zaafrane and Negga oases

	Depth (cm)	Amended oasis soil		Untreated oasis soil	
		BD (g/cm³)	Porosity (%)	BD (g/cm³)	Porosity (%)
Negga	0-20	1.35 ±0.33	49.05 ±0.29	1.54 ±0.45	41.88 ±0.22
	20-40	1.41 ±0.52	46.79 ±0.31	1.56 ±0.57	41.13 ±0.31
	40-60	1.46 ±0.39	44.90 ±0.16	1.56 ±0.49	41.13 ±0.14
	60-80	1.52 ±0.12	42.64 ±0.23	1.57 ±0.51	40.75 ±0.29
Zaafrane	0-20	1.32 ±0.31	50.18 ±0.24	1.41 ±0.39	46.79 ±0.22
	20-40	1.34 ±0.22	49.43 ±0.17	1.43 ±0.42	46.03 ±0.13
	40-60	1.38 ±0.16	47.92 ±0.12	1.46 ±0.46	44.90 ±0.30
	60-80	1.45 ±0.41	45.28 ±0.30	1.51 ±0.41	43.01 ±0.11

Table 3. Soil hydraulic conductivity in Zaafrane and Negga oasis

Oases	Hydraulic conductivity In amended Oases (cm h-1)	Hydraulic conductivity Untreated Oases (cm h-1)
Zaafrane	12.44 ±0.42	8.87 ±0.34
Negga	8.49 ±0.38	4.82 ±0.29

4. Conclusion

The results obtained on the study of the soils in the two oases Negga and Zâafrane show that the addition of sand and the organic amendment is a smart and efficient method in order to maintain and improve the productivity of the soils in these two oasis systems.

References

Bouajila A., Brahim N., Gallali T. (2016). Rôle des différentes fractions organiques dans la stabilité structurale des sols à textures riches en sables du nord et du centre de la Tunisie. Étude et Gestion des Sols, 79-92.

Bousnina H. (1993). Thèse de doctorat Bonification de régime hydrique des sols sableux des zones arides par un amendement argileux (Etude dans une oasis de sud tunisien). Belgique.

Bousnina H. (2004). Mouvement de l’eau dans les sols sableux des oasis du sud. séminaire organisé par le CRDA de Kébili.

Ghazouani W. (2009). Thèse : De l’identification des contraintes environnementales à l’évaluation des performances agronomiques dans un système irrigué collectif. Cas de l’oasis de Fatnassa (Nefzaoua, sud tunisien). Montpellier, France : l’Ecole Nationale du génie Rural, des Eaux et des Forêts.

Ibrahim H, Slama A, Brahim N. (2019). Influence of climatic and geographic factors on the spatial distribution of soil organic. Journal of Research in Environmental and Earth Sciences, 210-215.

Jendoubi D., Taamalah H., Moussa M. (2014). Suivi des effets des amendements organiques (fumier ovin et fumier camelin) sur les propriétés chimiques de sol dans les régions arides Tunisiennes. Revue des Régions Arides - Numéro Spécial - n° 35, 1581-1594.

Mlih R., Bol R., Amelung W., Brahim N. (2016). Soil organic matter amendments in date palm groves of the Middle Eastern and North African region: a mini-review. Journal of Arid Land, 77-92.

Tong X., Xu M., Wang X., Bhattacharyya R., Zhang W., Cong R. (2014). long terme fertilisation effects on organic carbon fractions in a red soil of China. Catena 113, 251-259.

Yang R., Su Y.Z., Wang T., Yang Q. (2016). Effect of chemical and organic fertilization on soil carbon and nitrogen accumulation in a newly cultivated farmland. Integr.Agric, 658-666.

Zhang W., Xu M., Wang X., Huang Q., Nie J., Li Z., Li S., Hwang S.W., Lee K.B. (2012). Effects of organic amendments on soil carbon sequestration in paddy fields of subtropical china. soil sediments 12, 457-470.

Zebarth B.J, Neilsen G.H., Hogue E, Neilsen D. (1999). Influence des amendements faits de d.echets organiques surcertains proprietes physiques et chimiques due sol. Canadian Journal Soil Sciences 79, 501-504.