EQA – Environmental quality/Qualité de l'Environnement/Qualità ambientale, 5 (2010) 1-6

EFFECTS OF OLIVE MILL WASTEWATER SPREADING ON THE PHYSICAL CHARACTERISTICS OF SOIL

EFFETS DE L'ÉPANDAGE DES MARGINES (RÉSIDUS DE MOULINS À OLIVES) SUR LES CARACTÉRISTIQUES PHYSIQUES DU SOL

EFFETTI DELLE ACQUE REFLUE DA FRANTOI OLEARI SULLE CARATTERISTICHE FISICHE DEL SUOLO

Hamdi Sahraoui [(1)*], Hafedh Jamil Mellouli [(2)]

[(1)] Faculté des Sciences de Bizerte, Tunisia
[(2)] Institut National de la Recherche Agronomique de Tunisie, Ariana, Tunisia
[*] Corresponding author : E-mail rhamdi@uvigo.es

Abstract

The use of olive mill wastewater (OMW) by agricultural spreading constitutes an alternative among the solutions proposed. The experiment was carried out in Sidi Bou Ali (Tunisia), with three treatments, T_0, T_1 (25 m^3/ha) and T_2 (50 m^3/ha) during four months. By means the physical capillary model for porous media, pF curves were established and the effects of OMW on the soil physical characteristics were studied. It was concluded that the OMW, for the two applied doses, induced a decrease in water retention for all tensions. An increase in saturated state hydraulic conductivity was obtained in a more pronounced manner in the case of topsoil for all dates. These results confirm the migration process of OMW from the topsoil to the underlying horizon. Such soil modifications are already required in order to establish a mulch on the soil surface so as to reduce the evaporation water losses.
Key words: *olive mill wastewater (OMW); spreading; physical impacts; water retention*

Résumé

L'épandage agricole des margines constitue une alternative parmi les solutions permettant de les valoriser. L'expérimentation a été réalisée à Sidi Bou Ali (Tunisie), avec trois traitements, T_0 (Contrôle) T_1 (25 m^3/ha) et T_2 (50 m^3/ha) pendant quatre mois. Par l'application du modèle capillaire physique du milieu poreux, des courbes de pF ont été établies et les effets des margines sur les caractéristiques physiques du sol ont été étudiés. Il a été conclu que les margines ont induit une diminution de la rétention d'eau à toutes les teneurs. Une augmentation de la conductivité hydraulique saturée a été obtenue d'une manière plus prononcée dans le cas de la couche arable pour toutes les dates. Ces résultats confirment le processus de migration des margines de la surface à l'horizon sous-

DOI: 10.6092/issn.2281-4485/3805

jacent. Ces modifications du sol sont déjà tenues en vue d'établir un mulch pour réduire les pertes d'eau par évaporation.
Mots clés: *margines; épandage; impacts physiques; rétention d'eau*

Riassunto

L'applicazione agricola di acque reflue dei frantoi oleari (ARO) è un'alternativa tra le opzioni per migliorarla. L'esperimento è stato effettuato a Sidi Bou Ali (Tunisia), con tre trattamenti, T_0, T_1 (25 m^3/ha) e T_2 (50 m^3/ha) per quattro mesi. Attraverso il modello fisico capillare del mezzo poroso, le curve pF sono state stabilite e gli effetti delle ARO sulle caratteristiche fisiche del suolo sono stati studiati. Si è concluso che le ARO hanno indotto una riduzione della la ritenzione idrica per tutte le tensioni più marcate. Un aumento di conduttività idraulica satura è stato ottenuto in modo più pronunciato nel caso dello strato superficiale per tutte le concentrazioni. Questi risultati confermano il processo di migrazione di ARO dal topsoil all'orizzonte sottostante. Tali modifiche del suolo sono già tenute al fine di stabilire un pacciame sulla superficie del suolo per ridurre le perdite di evaporazione dell'acqua.
Parole chiave: *acque reflue dei frantoi oleari; la diffusione; l'impatto fisico; la ritenzione idrica*

Introduction

The olive mill wastewater (OMW) is a complex composition effluent. Around 700,000 m^3 of OMW are produced in Tunisia per year (Ammar et al., 2004; Sellami et al., 2008). Faced with this enormous quantity, environmental solution for recovery of this effluent has become urgent. Their use as fertilizer by spreading to enrich the soil nutrient status has attracted attention, both in Tunisia and the Mediterranean country in general. The bonding and hydrophobic properties of OMW have been demonstrated in controlled conditions, as factors conditioning the soil surface. It has acquired a structural stability and hydrophobicity enabling it to fully play the role of mulch reduces water loss by evaporation (Mellouli, 1996). All times, results on changes in soil physical properties have not been definitively validated in situ. The objective of this study was to characterise the changes in water retention and hydrodynamic conductivity of soil, and their effect on soil behaviour followed the treatments and over time.

Materials and methods

Experimental protocol

The tests of this study were conducted in a parcel located in Sidi Bou Ali (Tunisia). The plots did not receive any contribution from OMW previously. The soil sampling was conducted monthly for four months after application (D_1, D_2, D_3, and D_4), at two horizons P_1 and P_2 (0 - 20 cm and 20 - 40 cm). Two doses of OMW were selected for application in the field, including 25 (T_1) and 50 (T_2) m^3/ha compared to untreated control (T_0).

Physical analysis

Water retention. To study the effect of OMW on water retention by the soil, moisture characteristic curves, commonly called pF curves were established. The pF is the logarithm of potential matrix in absolute value expressed in cm of water. Thus, the humidity at different potentials matrixes, ranging from -10 cm (± to saturation) to -15300 cm (permanent wilting point) was determined. The model of van Genuchten (1978) was applied for smoothing the curves of water retention θ (h), using the experimental values, with the following equation:

$$\theta = \theta r + (\theta s - \theta r) \times \left[\frac{1}{1 + (\alpha |h|)^n} \right]^m$$

Where θr and θs are the volumetric water content and residual saturation, α, m and n are the adjustment coefficients with m = 1-1 / n (van Genuchten, 1980).

Saturated hydraulic conductivity (K_S). Saturated hydraulic conductivity (K_S) was determined using the method of constant load. Rings with a cross section (A) and height (L) were filled with soil to a dry bulk density similar to that of testing the water retention. After stabilization of the flow of water, percolated volumes (V) were recorded for a period of one hour (t). Then, the different values of K_S were determined using Darcy's law:

$$K_S = \frac{V}{A \times t} \times \frac{L}{\Delta H}$$

Statistical treatment of results

The statistical treatment of results is achieved by software STAITSTICA (ver.V), (France Stat Soft, 1998). The results have been reported to an analysis of variance to one factor by the test of Fisher-Snedecor at the risk threshold of 5%.

Results and Discussion

Effect of dose administered on water retention

The parameters of the equation of Van Genuchten (1978 et1980) were determined with the experimental values of water retention. We obtained a smooth of the curve established by comparing the values of pF depending on the moisture density by treatment (T_0, T_1 and T_2) and date (D_1, D_2, D_3 and D_4) after application, for the two horizons (0 -20 and 20 - 40 cm). From the quantitative point of view, the OMW generate a decrease in water content, whatever the soil matric potential. Figures 1 and 2 show that both T_1 to T_2 for the effect on the OMW reducing water retention is increasingly important function of the time, but in a quantitative manner.

DOI: 10.6092/issn.2281-4485/3805

Hydraulic conductivity in saturated condition K_S

Figure 3 and 4 show that K_s increases significantly for T_1 and T_2 compared with T_0, the 2nd and 3rd month (D_2 and D_3).

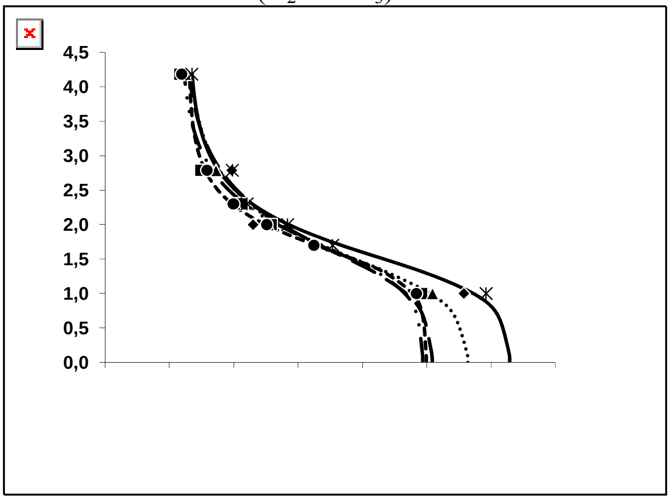
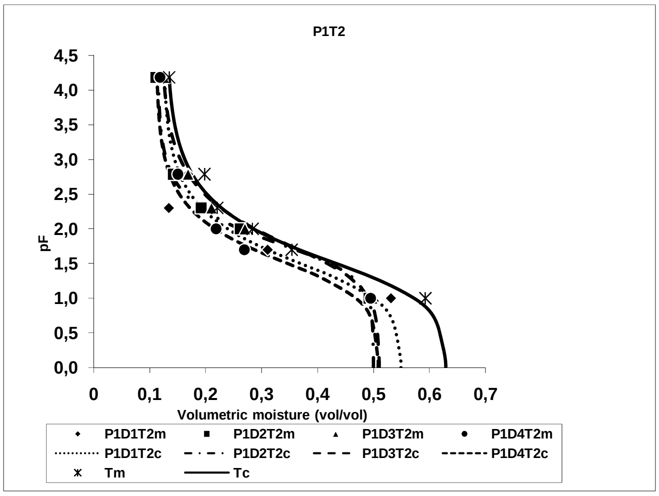


Figure 1

Effect of OMW application on water retention with treatment T_1 and T_2 at the horizon P_1.



Indeed, there is a significant increase of Ks which gradually dropped to the date D2 from 14,64 (T_0) to 21.71, and 22.24 cm/h respectively for T_1 or T_2.

Hydraulic conductivity in saturated condition K_S

Figure 3 and 4 show that K_s increases significantly for T_1 and T_2 compared with T_0, the 2nd and 3rd month (D_2 and D_3). Indeed, there is a significant increase of Ks which gradually dropped to the date D2 from 14,64 (T_0) to 21.71, and 22.24 cm/h respectively for T_1 or T_2. At the time D_3 treatment T_1 was significantly different from T_0, whereas these two treatments are significantly similar to T_2. No significant differences in Ks values were obtained at P_2 on the horizon for all treatments and for all dates are taken separately. However, on date D_3, there is a quantitative increase of Ks values increased from 16.67 in the case of T_0 to 18.17 and 22.53 cm/h respectively for T_1 and T_2.

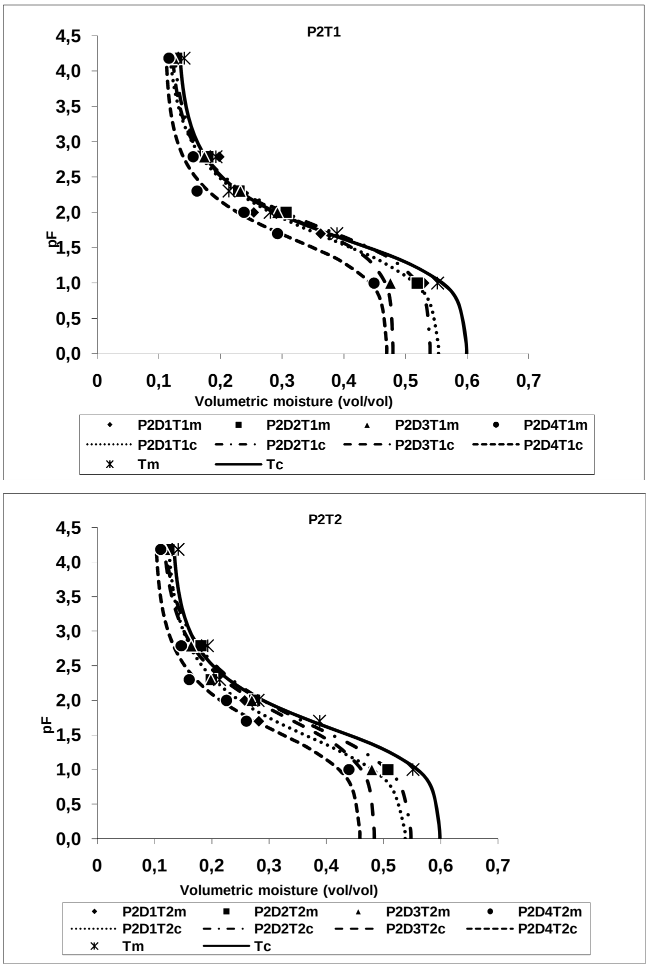


Figure 2

Effect of OMW application on water retention with treatment T_1 and T_2 at the horizon P_2.

General discussion

En general, the study has confirmed the effects of their hydrophobic and binding characteristics and reached the following conclusions: (i) A decrease in water retention in the two horizons with a greater importance in the surface horizon. This was found in a comprehensive manner for all dates from spreading. (ii) An increase in saturated hydraulic conductivity was obtained in a manner more pronounced in the case of the surface layer for all sampling dates for the underlying. (iii) The changes of soil physical properties, particularly more pronounced in the surface horizon, indicate that, consistent texture throughout its profile, has acquired a new

DOI: 10.6092/issn.2281-4485/3805

hydrodynamic behaviour can be simulated to a laminate floor, with layers of texture becoming finer from its surface (Mellouli et al, 1998). The surface layer play the role of hydrophobic mulch modifying the behaviour of water in the soil profile and reduce water loss through evaporation.

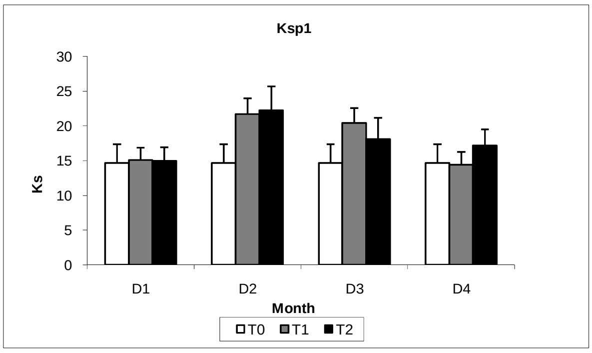


Figure 3

OMW doses effects on saturated hydraulic conductivity (Ks) by date after application at the P_1 horizon

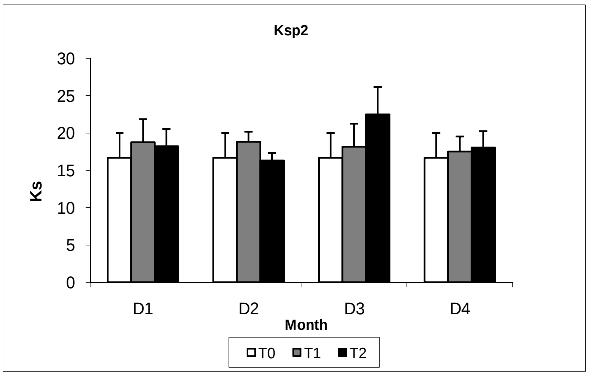


Figure 4

OMW doses effects on saturated hydraulic conductivity (Ks) by date after application at the P_2 horizon

References

AMMAR E., MEKKI H., UENO S., BEN ZINA M. (2004)Traitement de l'effluent des huileries d'olive et son intégration dans des briques de construction. Ann. Chim. – Sci. Mat. 29: 33–46.

MELLOULI H.J.(1996) Modifications des caractéristiques physiques d'un sable limoneux par les effluents des moulins à huile d'olive. Thèse de Doctorat en Sciences Biologiques Appliquées: Faculté des Sciences Agronomiques et Biologiques Appliquées de l'Université de Gand-Belgique. 255 p.

MELLOULI H.J., HARTMANN R., GABRIELS D., CORNELIS W. M. (1998) The use of olive mill effluents (margines) as soil conditioner mulch to reduce evaporation losses. Soil and Tillage Research, 49: 85-91.

SELLAMI, F., JARBOUI, R., HACHICHA, S., MEDHIOUB, K., AMMAR, E. (2008) Co-composting of oil exhausted olive-cake, poultry manure and industrial residues of agro-food activity for soil amendment. Bioresour.Technol. 99: 1177–1188.

STAT SOFT France (1998) STATISTICA (ver.V) Logiciel de statistique.

VAN GENUCHTEN M.TH. (1978) Calculating the unsaturated hydraulic conductivity with a new closed form analytical model. Research Report 78-WR-08, Water Resources Program, Dep. Of Civil Engineering, Princeton Univ., Princeton N.J.

VAN GENUCHTEN M.TH. (1980) A closed form equation for predicting the hydraulic conductivity of unsaturated soils. Soil Sci. Soc. Am. J., 44: 892-898.

DOI: 10.6092/issn.2281-4485/3805