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The Olive Mills Waste Water (OMW) as an Organic Amendment for Controlling Wind Erosion in Southern Tunisia by Improving the Soil Surface Structure

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Abstract: Spraying OMW on poor sandy soils in the olive orchards induces increasing of the organic matter content, the formation of aggregates and improving the soil structure stability. Hence, OMW can be an alternative and effective way to control this polluting sewage. Since 1995 a field experiment is running in an olive plot in chammakh-Zarzis, south Tunisia, where rates of 50, 100 and 200 m^3 of OMW were sprayed yearly on 1 ha fields with 16 olives trees per ha. Data collected in 2006 showed an increase in organic matter content from originally 0.06 to 1.27 %, an increase in the amount of aggregates > 2 mm to 34%, and an increase in the threshold friction velocity for deflation to 12 m sec^{-1} for the 200 m^3 ha^{-1} application.

Key words: Aggregates, Friction velocity, Olive mills waste water, Organic matter, Tunisia

1. Introduction

Soil degradation especially related to detoriation of its physical properties is a common problem in southern Tunisia. One of its most appearent manifestations is the surface crust formation and the reduction of the vegetation cover due to water and wind erosion. Increasing the organic matter content in sandy soils can increase the aggregate formation and stability and reduce its vulnerability to erosion.

The quantities of Olive Mills Waste water, accumulating each year and dumped in open reservoirs and lakes; constitute also a real environmental problem in Tunisia. They can be used as an organic amendment for improving soil physical properties (Mellouli, 1996). The main chemical characteristics of this sewage are reported in **Table 1**.

The objective of this study is to evaluate the impact of 10 years of successive OMW sprays on the surface properties of sandy soils in olive orchards in southern Tunisia. This work is a joint venture of the Institut de l'Olivier, Zarzis, Tunisia, The institut des Régions Arides, Médenine, Tunisia and the Unesco Chair on Eremology, Ghent University, Belgium, And SOPHIU, Soil Erosion and Soil Physics Research Group of the Department of Soil Management, Ghent University, Belgium.

2. Materials and methods

2.1. Study zone

The study zone is located at Chammakh-Zarzis in the south eastern Tunisia. The climat of this region is an arid Mediterranean climate with an annual average rainfall of 180 mm (i.e. long term average for the period 1923-2004). The soil of this area is moderately deep with a slight texture, very filterable and relatively poor in organic matter.

2.2. Methodology

2.2.1. On site Application of the OMW

The OMW spray is insured by an empty pit citern manipulated by a tractor takeover power. The OMW is homogeneously spread on the soil with the respective doses of 50 m^3/ha, 100 m^3/ha and 200 m^3/ha.

Table 1. Chemical characteristics of OMW (the major elements).

Elements	H (%)	pH water	Ce (mS/cm)	M matter (g/l)	K (g/l)	O. matter (g/l)	Reducing sugar (g/l)	Phenols (g/l)
Value	87,9	5,5	18,6	13,7	7,5	107,0	11,4	5,8

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Another field called witness field remains without any treatment (0 m^3/ha)). The treatments were applied for 10 years: since 1996 till 2006 during the month of January. Each treated plot covered a surface of one hectare (16 olive trees in full production and aged between 60 to 70 years) and separated by 2 non-treated olive trees rows (48 m) .

2.2.2. Monitored parameters

2.2.2.1. The Organic matter

The organic matter rate was determined by Walkley and Black methods which consisted on cold oxidization with bichromate of potassium ($K_2Cr_2O_7$) in acid environment and titration with ferrous sulfate ($FeSO_4,7H_2O$). The organic matter rate was calculated by the fellow equation:

MO% = C% x 1.725

2.2.2.2. Aggregate and structural stability

The OMW effects on soil structural stability were determined in laboratory for three doses (50, 100, 200 m^3/ha). The stability is expressed as a difference in status of the soil before (initial status) and after (final status) a force is applied. Therefore it is necessary to assess the initial and final status of the aggregates. Soil aggregates have different sizes (diameter) and the aggregate size distribution (expressed in % of the different diameter fractions) can fit a log-normal distribution. The aggregate size distribution can be characterised by the mean weight diameter MWD.

To determine the structural stability we should:

1. calculate the mass of the rain drop.
2. calculate the MWD after dry (MWD_d)and after wet (MWD_w) sieving

$$MWD = \frac{\sum_{i=1}^{i=n} m_i d_i}{\sum_{i=1}^{i=n} m_i}$$

Where m_i = mass of aggregate fraction I,

d_i = mean diameter of fraction I,

3. calculate the instability index (IS) using following expression :

$$IS = MWD_{dz} - \mathrm{MWD}_{nz}$$

$$si = \frac{1}{IS}$$

4. calculate the instability index (*IS*) using following expression :
5. plot the aggregate size distribution after dry and after wet sieving.

2.2.2.3. Threshold friction velocity

Laboratory wind tunnel simulations have been carried out to study the effect of wind erosion on a treated surface where different doses of OMW were spread in the upper soil layer (0 m^3/ha, 50 m^3/ha, 100 m^3/ha and 200 m^3/ha). For each treatment we had determined the threshold friction velocity u_{*t} using Cornelis and Gabriels methods (Cornelis and Gabriels, 2004) in the International Centre for Eremology (I.C.E). The I.C.E wind tunnel simulator used is the one described by Cornelis *et al*. (2004). It is a closed circuit blowing –type wind tunnel with a 12m long, 1.2 m wide and 3.2 m high working section (Gabriels *et al.,* 1997). The boundary layer was set at about 0.60 m using a combination of spires and roughness elements (Cornelis, 2002).

For the static Analysis, we have used the STATGRAPHICS Plus 5.1. LSD test was used to find any significative difference between treatment means.

3. Results and Discussions

3.1. Organic mater

When the organic matter is injected in the soil, its structural stability is directly affected first because of the immediate physico-chemical changes (abiotic factors), then, again during the decomposition of the organic matter brought by micro-organisms activated by the sugar (source of energy) present in the OMW (biologic factors). Rich in organic substances (107 kg/m^3), the OMW spray improved the content of soil in these substance. Indeed, the organic matter rate, initially very weak (0.06), raised to 0.41%, 0.71% and 1.27% respectively for the doses of 50 m^3 / ha, 100 m^3/ha and 200 m^3/ha after ten successive years of OMW spray (**Table 2**). Therefore, the organic matter rates increase is proportional to the applied doses. The differences observed could be explained by the kinetics of the organic matter mineralization process which depends on the quality and quality of micro-organisms in the treated soil. Similar results were obtained by Cabrera *et al*. (1996) who indicate that the yearly supply, during three years, of 37 l/m² or 61 l/m² of OMW, on sandy soil with an initial organic matter rate of 0.45 %, could increase the organic matter

Table 2. Evolution of organic matter rate after 10 years of OMW spray.

Doses	T0		T1		T2		T3	
Mean	0.35 ± 0,12	a	0,49 ± 0,13	ab	0,60 ± 0,21	b	1,05 ± 0,28	c

Table 3. Aggregate and Structural stability.

Doses	T1		T2		T3	
% Aggregate > 2mm	7,32 ± 1,45	a	12,78 ± 3,17	a	33,93 ± 5,73	b

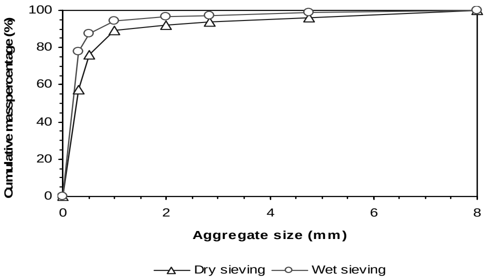

Fig. 1. Aggregate size after spreading 50 m^3 ha^{-1}.

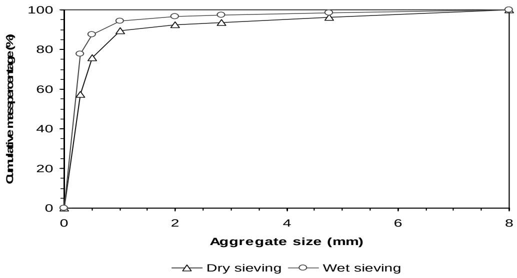

Fig. 2. Aggregate size after spreading 100 m^3 ha^{-1}.

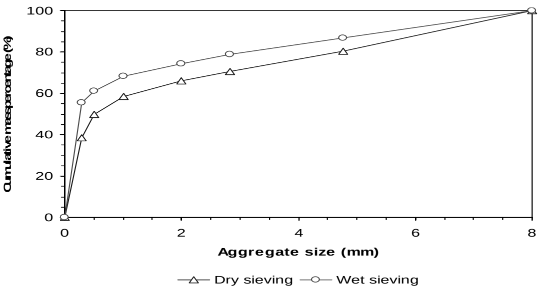

Fig. 3. Aggregate size after spreading 200 m^3 ha^{-1}.

content respectively to 1.62% and 1.98%. Organic amendment supply represented the principal cohesion factor between the soil aggregates. This observation is in agreement with results given by Oades (1993) and Angers and Cover (1996).

3.2. Aggregate and structural stability

It was only at rates of 200 m^3 ha^{-1} that differences in aggregate formation could be found. In the lower rates (50 and 100m^3 ha^{-1}) only 10% of the aggregates had diameters larger than 2 mm, at the 200 m^3 ha^{-1} rate, 35% of the aggregates had diameters larger than 2mm (**Table 3**).

The same samples were under water sieving test and allowed to break down. Once more the 200 m^3 ha^{-1} rate showed important differences compared to the lower application rates, where only 5% of aggregates had diameters bigger than 2mm. The 200 m^3 ha^{-1} application rate on the other hand still resulted in 25% of aggregates with diameters larger than 2mm, reflecting also a higher aggregate stability (**Figures 1**, **2** and **3**).

3.3. Threshold friction velocity

These results showed that the threshold velocity was raised with doses of OMW spray. These velocities are respectively 8.50 m/s and 12.5 m/s for 0 m^3/ha and 200 m^3/ha (**Table 4**). Therefore, wind erosion in orchard olive tree could be reduced. These results could be explained, by the increase of the organic matter. The same results are obtained by Mellouli (1996), Ben Rouina and Taamallah (1999) and Abichou (2003). They showed that OMW improve the mulch formation which can reduce water and wind erosion. Statistical analysis showed no significant difference between T0 and T1 but it was a high significant with T3.

Table 4. The threshold friction velocity values.

Doses	T0		T1		T2		T3	
Mean	**8,50 ± 0,15**	**a**	**8,65 ± 0,17**	**a**	**10,25 ± 0,16**	**b**	**12,15 ± 0,93**	**c**

4. Conclusion

A successive spreading of OMW in sandy soil, with doses bellow 200 m^3/ha, is without negative effect and induces a soil conglomeration thanks to its high content in organic matter. The organic matter rate increases the cementation of the soil aggregates. Therefore, the structural stability is improved and wind erosion is reduced. These results can be compared to those of Gabriels *et al*. (1975) obtained in sandy soil showing the efficiency of mulch constituted by the aggregate inferior to 5.5mm in thickness permitting therefore a better stability of soil and a substantial reduction of evaporation.

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