Pepper cultivation on a substrate consisting of soil, natural zeolite and olive mill waste sludge—Changes in soil properties

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Naxos, June 2018
Olive Mill Waste

Characteristics:
• Seasonal production (from November to February)
• High water content
• High organic load
• High content in polyphenols
• High electrical conductivity
• High content of nutrients (potassium, iron)
• High oil content

Management of olive mill wastes:
• Disposal in evaporation ponds
• Disposal on soils and on water recipients
• Treatment in special installations (production of soil improvers, use in the irrigation of the treated liquid part)
• Treatment and retrieval of phenols
OMW: Uncontrolled disposal on soils

LIFE PROSODOL

- pH
- Electrical Conductivity
- Organic Matter
- Total Nitrogen
- Available Phosphorus
- Exchangeable Potassium
- Polyphenols
- Available iron

<table>
<thead>
<tr>
<th>Olive wastes on soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Conductivity <strong>up to 10 mS/cm</strong></td>
</tr>
<tr>
<td>Exchangeable Potassium <strong>up to 20 cmol/kg</strong></td>
</tr>
<tr>
<td>Available Phosphorus <strong>up to 440 ppm</strong></td>
</tr>
<tr>
<td>Available Iron <strong>up to 380 ppm</strong></td>
</tr>
<tr>
<td>Total Nitrogen <strong>up to 20 mg/g</strong></td>
</tr>
<tr>
<td>Polyphenols <strong>up to 600 ppm</strong></td>
</tr>
</tbody>
</table>

Olive wastes on soil properties:

- Electrical Conductivity up to 10 mS/cm
- Exchangeable Potassium up to 20 cmol/kg
- Available Phosphorus up to 440 ppm
- Available Iron up to 380 ppm
- Total Nitrogen up to 20 mg/g
- Polyphenols up to 600 ppm
The 12 weeks greenhouse experiment

Solid Olive Mill Waste
3 doses
0%, 2.5%, 5.0%

3 doses of zeolite
(clinoptilolite)
0%, 2.5%, 5.0%

<table>
<thead>
<tr>
<th>0% ZEOLITE</th>
<th>2.5% ZEOLITE</th>
<th>5.0% ZEOLITE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z0AP0</td>
<td>Z1AP0</td>
<td>Z2AP0</td>
</tr>
<tr>
<td>Z0AP1</td>
<td>Z1AP1</td>
<td>Z2AP1</td>
</tr>
<tr>
<td>Z0AP2</td>
<td>Z1AP2</td>
<td>Z2AP2</td>
</tr>
</tbody>
</table>

The pepper seedlings were planted in 9 different soil/solid olive mill waste/zeolite mixtures. Each kind of mixture was placed in 4 pots. The experimental design was based on a split-plot pattern. Plants were irrigated every other day by adding 1000ml of water, while leachates, were collected and analyzed weekly. Peppers and pot soils were harvested and collected respectively, for further research and conclusions.

Naxos, June 2018
The 12 weeks greenhouse experiment

**Table 1: OMW properties**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic Matter, %</td>
<td>97</td>
</tr>
<tr>
<td>Electrical Conductivity, mS/cm</td>
<td>2,6</td>
</tr>
<tr>
<td>pH</td>
<td>4,10</td>
</tr>
<tr>
<td>Polyphenols, %</td>
<td>0,32</td>
</tr>
<tr>
<td>Nitrogen, %</td>
<td>0,51</td>
</tr>
<tr>
<td>Potassium, %</td>
<td>1,1</td>
</tr>
<tr>
<td>Calcium, %</td>
<td>0,11</td>
</tr>
<tr>
<td>Magnesium, %</td>
<td>0,05</td>
</tr>
<tr>
<td>Sodium, %</td>
<td>0,04</td>
</tr>
<tr>
<td>Phosphorus, %</td>
<td>0,05</td>
</tr>
<tr>
<td>Iron, mg/kg</td>
<td>41</td>
</tr>
<tr>
<td>Copper, mg/kg</td>
<td>12</td>
</tr>
<tr>
<td>Zinc, mg/kg</td>
<td>4,3</td>
</tr>
</tbody>
</table>
By increasing waste dose, the number of crops were increased. The highest waste dose resulted in the highest number of crops.

Zeolite seems to affect the number of crops.

For no waste case, increased zeolite percentage seems to increase crops number, but....

Zeolite and waste effect: Delays in crops growth. The first crops were harvested with two weeks delay.
Crops Fresh (FWT) and Dry Weight (DWT)
But if only the increased waste amount increases yield, is zeolite necessary?
With 0% zeolite: increased leaching as waste dose increases
As zeolite dose is increasing, leaching is inhibited, therefore
1. Prevent leaching of nutrients
2. Keep nutrients in soil
Exchangeable Potassium in the substrate

K, cmol/kg

Treatments
…but this results to higher substrate EC
Although effects of waste and zeolite doses can be seen, in general the EC of the leachates are considered low .... ..and also in comparison with what is happening when fertilizers are added on soils!!!
Boron in Substrates

![Bar chart showing B, mg/kg for different treatments.](image)
Available Fe in Substrates

Fe, mg/kg

Treatments
High Na concentrations released mainly during the first 3 weeks, which then reduced. It is due to zeolite, and increases as zeolite dose increases. However, ESP remains < 6 (no salinity risk) ...but it affects production (e.g. Delays, less crops)

\[(Na_{0.2}K_{0.6}Mg_{0.7}Ca_{2.0}Al_{6.2}Si_{2.9}O_{72} \cdot 19.6H_2O)\]
Sodium in Substrates

- Organic matter of OMW increases the number of crops harvested and also the fresh and dry weight of the crops
- Zeolite prevent leaching of potassium and keep K in the substrate
- The EC of the substrate increases but it's not considered risky for the 2.5% of zeolite and waste
- It is necessary to foresee a period of 2-3 weeks to wash Na from the substrate
- Compared to fertilization, the substrate used produced leachates with significant lower Electrical conductivity
- Because of the high Na content, the increased EC of soil and substrate, the delays in crop growth, the case of Z1AP1 or Z1AP2 (?) seem to be more appropriate, but measurements in crops are still in progress......
Thank you for your attention

Dr. Maria K. Doula

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