Degradation of mesotrione in amended soils and response of soil microbial communities

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Introduction

Research on the impacts of some agricultural management practices, such as application of pesticides and organic amendments on soil microbial communities is necessary and barely known currently (Hussain et al., 2009). Mesotrione is an herbicide used to control some grass and broad-leaved weeds and is usually applied in amended soils. The degradation of this herbicide and the formation of possible degradation products in an unamended vineyard soil and this soil amended with three different organic residues (sewage sludge, green compost and commercial pellets) is being studied under laboratory conditions. Furthermore, the response of soil microbial communities to the simultaneous application of organic residues and mesotrione to the soil is being assessed by a broad-scale microbial community analysis (soil dehydrogenase activity, respiration and microbial biomass) over the incubation period.

Material and methods

Mesotrione has a log \( K_{ow} = 0.11 \) and a water solubility of 160 mg L\(^{-1}\).

The organic residues used were sewage sludge (SS), green compost (C) and commercial pellets (P) with organic carbon (OC) content of 27.0\%, 10.6\% and 22.2\%, respectively.

Soil samples were collected from the surface horizon (0-30 cm) of a vineyard in Toro, Zamora (Spain). Its texture was classified as sandy loam. Amended soils were prepared in the field by uniformly mixing of soils with SS, C or P at rate of 50 t ha\(^{-1}\). Unamended and amended soils were incubated outdoors for one month. Their characteristics are included in Table 1.

<table>
<thead>
<tr>
<th>Soil (S)</th>
<th>pH</th>
<th>OC (%)</th>
<th>N (%)</th>
<th>C/N</th>
<th>DOC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>6.29</td>
<td>0.49</td>
<td>0.04</td>
<td>11.8</td>
<td>0.005</td>
</tr>
<tr>
<td>S+SS</td>
<td>6.16</td>
<td>2.20</td>
<td>0.35</td>
<td>6.30</td>
<td>0.068</td>
</tr>
<tr>
<td>S+C</td>
<td>7.26</td>
<td>0.71</td>
<td>0.07</td>
<td>10.2</td>
<td>0.007</td>
</tr>
<tr>
<td>S+P</td>
<td>7.34</td>
<td>1.73</td>
<td>0.12</td>
<td>14.0</td>
<td>0.035</td>
</tr>
</tbody>
</table>

The pesticide dissipation experiments (Lynch et al., 1995) were conducted in duplicate. Mesotrione was added to unamended and amended soils (500 g) to obtain a final concentration of 2 mg kg\(^{-1}\). Soils were incubated at 20°C in the dark and moisture was adjusted to 40% of the maximum soil water holding capacity. Sampling was performed at different times. Soil was extracted and pesticide determination was accomplished by HPLC/DAD/MS using a Waters chromatograph (Waters Assoc., Milford, MA, USA). Formation of metabolites during the dissipation experiment was monitored.

Soil dehydrogenase activity (DHA) was determined in soil samples at different times after fungicide application. The response of soil microbial communities (respiration and microbial biomass) to mesotrione was studied at 0 and 28 days in samples with mesotrione applied at three different doses (2, 10 and 50 mg kg\(^{-1}\)).
The dissipation kinetics for the pesticides was fitted to a single first-order kinetic model or Gustafson and Holden model (first-order multicompartment model).

Results

The degradation kinetics of mesotrione fitted the single first-order kinetics (SFO) better. Results indicated that the degradation rates of mesotrione followed the order: soil > soil+P ≥ soil+C > soil+SS (Figure 1), indicating the influence of the organic amendment and its OC content on the degradation process. At the beginning of the incubation period, soil dehydrogenase activity was stimulated by the addition of amendments compost and pellets, and by the addition of the herbicide (up to 3 times higher in soil+C+mesotrione). Respiration was stimulated in soil+C and soil+P and microbial biomass was increased in unamended and SS-amended soils at the beginning of the incubation period in samples with the highest mesotrione dose added.

Figure 1. Degradation kinetics of mesotrione in unamended and amended soils.

Conclusions

Organic amendments decreased the degradation rate of mesotrione in amended soils. Mesotrione affected DHA, respiration and biomass and the effects depended on the soil treatment and herbicide dose. Studies are currently being carried out and need to be completed to obtain definitive results, which permit to understand the environmental impact of herbicides and organic residues on the soil microbial response in order to assess the potential ecotoxicity and risk when this herbicide is applied in amended soils.

References
