Nematicidal effect of volatile organic compounds (VOCs) on the plant-parasitic nematode *Meloidogyne javanica*

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Previous studies have demonstrated that volatile organic compounds (VOCs), produced by the yeast *Saccharomyces cerevisiae*, were able to inhibit the development of phytopathogenic fungi. In this context, the nematicidal potential of the synthetic mixture of VOCs, constituted of alcohols and esters, was evaluated for the control of the root-knot nematode *Meloidogyne javanica*, which causes losses to crops of high economic value. The fumigation of substrate containing second-stage juveniles with VOCs exhibited nematicidal effect higher than 30% for the lowest concentration tested (33.3 µL g⁻¹ substrate), whereas at 66.6 and 133.3 µL g⁻¹ substrate, the nematode mortality was 100%. The present results stimulate other studies on VOCs for nematode management.

Additional Keywords: phytonematode, nematicide, fumigation, alternative control

**RESUMO**


**Palavras-chave adicionais:** fitonematóide, nematicida, fumigação, controle alternativo
side, different volumes of the artificial mixture of VOCs (50, 100 and 200 µL) were added to a cotton wool to obtain the concentrations of 33.3, 66.6 and 133.3 µL g⁻¹ substrate. Immediately after the addition of compounds, the plates were sealed and maintained at 27 °C in the dark. The control treatment consisted of plates containing the nematodes in the absence of VOCs. A total of 10 replicates were conducted for each treatment. After five days, the fumigated vermiculite was collected and transferred to a modified Baermann system (4), where it was maintained for five days at 30 °C. This procedure recovered only live nematodes after the treatment, which were counted using a stereoscope.

RESULTS AND DISCUSSION

An average of 40 and 27 nematodes were recovered, respectively, from the control and at the concentration of 33.3 µL g⁻¹. In contrast, at 66.6 and 133.3 µL g⁻¹ no nematodes were recovered. At the lowest concentration tested, the VOCs treatment resulted in the mortality of nearly one third of the nematodes when compared to control after 5 days of fumigation, while at higher concentrations all nematodes died (Figure 1). Previous work showed that the artificial mixture of VOCs or some of the components used alone were able to reduce the development of phytopathogenic fungi (2). The present assay proved that VOCs of S. cerevisiae also cause high mortality of plant parasitic nematodes.

There is limited research on the effect of microbial VOCs on plant-parasitic nematodes. The biofumigation with VOCs produced by the fungus Muscodor albus showed nematostatic and nematicidal effect on the nematodes Meloidogyne chitwood, M. hapla, Paratrichodorus allius and Pratylenchus penetrans in the roots and rhizosphere of beans, potatoes and pepper (5).

Grimme et al. (3) found that fumigation with volatiles produced by M. albus caused 74 and 100% mortality of M. incognita in the soil after 72 hours and 7 days of treatment, respectively. In in vitro assays, 5 ml mL⁻¹ of the artificial mixture of VOCs caused 100% mortality after 24h, while in in vivo assays, the concentration of 1.67 ml per cm³ of sand resulted in fewer galls on tomato roots. The formulation described in those experiments contained compounds such as 3-methyl-1-butanol, 3-methyl-1-butanol acetate and some esters of propanoic acid, whereas in the present work the main compounds were ethanol, 3-methyl-1-butanol and 2-methyl-1-butanol. The last two compounds were responsible for most antimicrobial activity against phytopathogenic fungi (1, 2). However, the specific compounds responsible for the mortality of the plant-parasitic nematodes have not been identified yet.

The present information stimulates further studies to evaluate the potential of these compounds in the control of nematodes and open

<table>
<thead>
<tr>
<th>Peak</th>
<th>Compound</th>
<th>Retention time (min)</th>
<th>Area (units)</th>
<th>Relative (%)</th>
</tr>
</thead>
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<tr>
<td>1</td>
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<td>2.10</td>
<td>21,478</td>
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<tr>
<td>2</td>
<td>Unidentified</td>
<td>2.91</td>
<td>376</td>
<td>1.5</td>
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<td>Ethyl acetate</td>
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<td>450</td>
<td>1.8</td>
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<td>4</td>
<td>3-methyl-1-butanol</td>
<td>5.15</td>
<td>1,736</td>
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</tr>
<tr>
<td>5</td>
<td>2-methyl-1-butanol</td>
<td>5.23</td>
<td>611</td>
<td>2.4</td>
</tr>
<tr>
<td>6</td>
<td>Phenylethyl alcohol</td>
<td>27.15</td>
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<tr>
<td>7</td>
<td>Ethyl octanoate</td>
<td>28.30</td>
<td>362</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Table 1. Composition of VOCs produced by S. cerevisiae, grown on potato dextrose agar, identified by using GC-MS (1).

Figure 1. Nematicidal effect of the artificial mixture of VOCs, identified from S. cerevisiae, on Meloidogyne javanica. The average values of 10 replicates (± SD) were calculated as percentage of death compared to control plates in the absence of volatiles. Means followed by the same letter do not differ according to Tukey’s test (p £ 0.01)
perspectives for a new alternative control method, as the soil fumigation with methyl bromide is no longer available due to high toxicity and damage to the ozone layer.

ACKNOWLEDGMENTS
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REFERENCES