EFFECT OF ROOT EXUDATES OF Tagetes sp. ON EGG HATCHING BEHAVIOR OF MELOIDOGYNE INCognITA

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ABSTRACT
The effect root exudates of pre-planted marigold intercropped with tomato in regulating the hatching behavior of root-knot nematode - Meloidogyne incognita eggs were investigated. Marigold cultivars Tagetes patula, T. minuta, T. erecta, T. erecta (var. Orange), T. erecta (var. Yellow) significantly reduced the numbers of second-stage juveniles (J2s) in subsequent tomato compared to the tomato-tomato control. Four different concentrations (25, 50, 75 and 100 %) of water soluble extract from the selected varieties of Marigold cultivars were filtered and added to the petri dish and infested with the eggs of M. incognita. Data indicate that egg hatching was significantly affected by root exudates of Tagetes sp. however, nematicidal activity was species dependent. Root exudates of T. erecta were lethal to J2 of M. incognita and were inhibitory to the hatch of eggs at the concentration of 75 % or higher.

Keywords: Meloidogyne incognita, Root-knot nematodes, Tagetes erecta, Tagetes patula, Tagetes minuta

INTRODUCTION
Plant diseases caused by parasitic nematodes are widespread. The mere presence of plant-parasitic nematodes in soil does not guarantee crop damage or yield loss, since a nematode population may remain below the damage threshold level for a specific field. Factors such as environmental conditions, soil type, previous cropping history, the specific nematode species and or race present, pathotype distribution, prevailing nematode distribution pattern, nematode multiplication rate, and plant cultivar grown will have a bearing on whether crop damage and yield reduction will be inflicted. Root-knot nematodes (Meloidogyne spp.) are obligate endoparasites of a wide range of plant species and globally cause large crop yield losses. The infective second stage juvenile (J2), hatches from an egg in the soil and must find a host and establish a feeding site in order to survive and complete its life cycle. Nematode population dynamics are density dependent and are influenced by host growth, reproductive potential and environmental factors. However, little is known about the influence of environmental parameters on the egg hatching behavior and survival of the infective juvenile.
The root knot nematode, Meloidogyne incognita, is an obligate parasite that causes significant damage to a broad range of host plants belonging to the families Solanaceae, Cucurbitaceae, Leguminosae, Liliaceae, Chenopodiaceae, Compositae, Umbelliferae, Cruciferae and Malvaceae. Meloidogyne incognita is also highly pathogenic to some staple crops such as cereals, including rice, maize, potato, soybean, banana, plantain, sweet potato and yam; industrial crops such as tobacco, coffee, sugar cane, sugar beet, cotton and black pepper. Meloidogyne incognita can infect 1,700 plant species. In particular, Meloidogyne incognita is a serious problem on a number of economically important agricultural crops including grape (Vitis vinifera), papaya (Carica papaya), guava (Psidium guajava), tobacco (Nicotiana tabacum), watermelon (Citrullus vulgaris) and tomato (Lycopersicon esculentum).
Meloidogyne incognita has been reported to increases the severity of bacterial wilt disease in plants. Moreover, farms infested with Meloidogyne incognita frequently experience a decline in the yield of subsequent crops. Current practice of management of Meloidogyne incognita in the field condition primarily relies on application of nematicides. However, because chemicals are of potential risk to the environment and human health, eco-friendly substitute to chemical nematicides are desirable.
Several plants have been shown to be effective in controlling nematodes on agricultural crops when grown in rotation, inter-planted with susceptible crops, or used as a soil amendment. Among these plants, marigold (Tagetes sp.) is used for its nematicidal properties against plant-parasitic nematodes. Marigold can suppress 14 genera of plant-parasitic nematodes, with lesion nematodes (Pratylenchus sp.) and root-knot nematodes (Meloidogyne spp.) the most affected. The suppression of Meloidogyne spp. by Marigold have been reported. African (T. erecta) and French (T. patula) marigolds are the most commonly used species. Each of the Marigold species consists of several varieties that differ in characteristics such as bloom size, shape, and color, as well as plant size and leaf shape. Although, marigolds had an overall suppressive effect on nematodes, French marigold cultivars (T. patula) was found to be most effective against wide range of nematodes.
The potential use of marigolds for the control of Meloidogyne species have been studied by several workers both in laboratory and in the field. Hackney and Dickerson attributed 1975 suppression of M. incognita and M. javanica to early non preference of the nematodes for marigold roots, but Suatmadji reported in 1969, that equal numbers of M. hapla invaded roots of tomato and marigold. When intercropped most cultivars of African marigold (T. erecta) and French marigold (T. patula) are effective in reducing the populations of M. incognita. However, selection of specific marigold species or cultivars to control targeted nematode pests seems to be the most important parameter for the effective control of the nematodes in the soil.
Alternatively, root-knot nematodes can be effectively managed without chemical pesticides. Some plant species are known to be highly resistant to nematodes. The best documented of these include marigolds (Tagetes sp.), rattlebox (Crotalaria spectabilis), chrysanthemum (Chrysanthemum sp.), castor bean (Ricinus communis), margosa (Azadirachta indica), and many members of the family Asteraceae. The allelopathic effect of marigold root exudates is responsible for nematicidal activity and suppression of the hatching of nematode eggs is attributed to α-terthienyl. Besides, the exudate inhibits the growth of disease promoting organisms such as fungi, bacteria, insects, and viruses. Further, nematicidal activity of marigold was detected in the root exudates but not in the homogenized extracts of roots and leaves. Planting of marigolds for 65 to 105 days in fields highly infected with root-knot or root-lesion nematodes resulted in significant decrease of nematode populations and increase in yields of subsequent crop up to 98 %.
Studies have shown that pre-planting resistant hosts significantly reduce nematode populations in the soil\textsuperscript{8,9,11}. Therefore, efficacy of *Tagetes* sp. as potential biocontrol agent in the management of *Meloidogyne incognita* was evaluated both in the field and soil amendment experiments. In addition, plant extracts and root exudates from selected *Tagetes* sp. were tested to determine the mechanism of nematode suppression by affecting the hatching behavior of the eggs.

Recently, it has been reported that use of marigold as nematode biocontrol agent significantly improves the nematode-suppressive effect\textsuperscript{16}. We hypothesize that marigolds suppress plant parasitic nematodes more effectively if it is planted right after a nematode-susceptible host, while targeted nematodes are still in their active yet vulnerable stage. This is because nematodes could undergo a survival stage and avoid coming into contact with allelopathic compounds released from marigold.

**MATERIALS AND METHODS**

A hail-net-cage experiment was followed by a microplot experiment during a consecutive season. Local *M. incognita* and tomato plants were used in the study. Hail-net-cage experiment: Black plastic bags (25,000 cm\(^2\) capacity) were filled with a methyl bromide-fumigated and steam-pasteurized, sandy-loam soil (3.9 % clay, 1.9 % silt, 93.6 % sand, 0.6 % organic material); pH of the soil was adjusted to 6.55. Plant nutrients were added according to a soil nutrient analysis and adjusted to 25,000 cm\(^2\) of soil (3.9 % sand, 1.9 % clay, 93.6 % silt, 0.6 % organic material) during a consecutive season. Hatching was observed after 7 days and percentage hatch of the eggs increased 10.38 % to 46.66 % from 12 to 72h in the control however, with significant variations among the selected cultivars of *Tagetes* sp.

Data indicate that two of the *Tagetes* sp. (*T. erecta* and *T. erosa* (var. Yellow)) were effective in the management of hatching of the nematode eggs and thus reduction in the population of the nematodes in the field (micro plot experiment). However, the other selected *Tagetes* sp. had no significant effect on nematode management (Fig. 1a-f).

Results of the present study suggest that *Tagetes* sp are an ideal antagonistic plant for use in the management of *M. incognita*. The roots of *Tagetes* exuded substances that were lethal to the J2 of *M. incognita* and inhibitory to egg hatch\textsuperscript{3}. Results indicate that *Tagetes* sp. could be used to manage *M. incognita* as a rotation crop, a co-planted crop, or a soil amendment for control of root-knot nematode. The relative value of nematode resistance in susceptible host plants in the presence of variable nematode population levels, however, has been demonstrated clearly in this study. Moreover, root exudates were selectively toxic to the plant-parasitic nematodes but not to free-living organisms hence, Marigolds are a source of cheap and effective nematicides of root knot nematodes.

**REFERENCES**

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### Table 1: Effect of Root Exudates of *Tagetes* sp. on egg hatching of *M. incognita*

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Conc. (%)</th>
<th>Control</th>
<th><em>T. palala</em></th>
<th><em>T. minula</em></th>
<th><em>T. erecta</em> (Orange)</th>
<th><em>T. erecta</em> (Yellow)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>25</td>
<td>10.38 ±0.33</td>
<td>4.32 ±0.12</td>
<td>6.32 ±0.37</td>
<td>20.73 ±0.37</td>
<td>5.12 ±0.42</td>
</tr>
<tr>
<td>24</td>
<td>25</td>
<td>18.74 ±0.29</td>
<td>8.32 ±0.26</td>
<td>12.23 ±0.45</td>
<td>28.66 ±0.44</td>
<td>10.23 ±0.47</td>
</tr>
<tr>
<td>36</td>
<td>25</td>
<td>23.66 ±0.33</td>
<td>12.32 ±0.30</td>
<td>14.32 ±0.64</td>
<td>32.72 ±0.48</td>
<td>14.12 ±0.51</td>
</tr>
<tr>
<td>48</td>
<td>25</td>
<td>30.64 ±0.34</td>
<td>23.67 ±0.29</td>
<td>15.87 ±0.34</td>
<td>45.76 ±0.54</td>
<td>15.89 ±0.59</td>
</tr>
<tr>
<td>60</td>
<td>25</td>
<td>37.44 ±0.37</td>
<td>32.77 ±0.26</td>
<td>23.56 ±0.35</td>
<td>51.75 ±0.43</td>
<td>28.66 ±0.58</td>
</tr>
<tr>
<td>72</td>
<td>25</td>
<td>43.66 ±0.53</td>
<td>38.62 ±0.10</td>
<td>30.76 ±0.37</td>
<td>60.67 ±0.39</td>
<td>35.23 ±0.59</td>
</tr>
</tbody>
</table>

Data represent mean value; n = 3

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![Figure 1a](https://example.com/figure1a.png)

Fig. 1a Percentage inhibition of *Meloidogyne incognita* population by the root exudates of selected cultivars of *Tagetes* sp. after 12h of treatment
Figure 1a Percentage inhibition of *Meloidogyne incognita* population by root exudates of selected cultivars of *Tagetes* sp. after 24 h of treatment

Figure 1b Percentage inhibition of *Meloidogyne incognita* population by root exudates of selected cultivars of *Tagetes* sp. after 36 h of treatment

Figure 1c Percentage inhibition of *Meloidogyne incognita* population by root exudates of selected cultivars of *Tagetes* sp. after 48 h of treatment

Figure 1d Percentage inhibition of *Meloidogyne incognita* population by root exudates of selected cultivars of *Tagetes* sp. after 60 h of treatment

Figure 1e Percentage inhibition of *Meloidogyne incognita* population by root exudates of selected cultivars of *Tagetes* sp. after 72 h of treatment

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