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# Control of Root-Knot Nematodes on Tomato by the Endoparasitic Fungus *Meria coniospora*[1]

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*Abstract:* The endoparasitic nematophagous fungus *Meria coniospora* reduced root-knot nematode galling on tomatoes in greenhouse pot trials. The fungus was introduced to pots by addition of conidia at several inoculum levels directly to the soil or addition of nematodes infected with *M. coniospora* to the soil; both methods reduced root galling by root-knot nematodes. These studies represent a part of a recently initiated effort to evaluate the potential of endoparasitic nematophagous fungi for biocontrol of nematodes.

*Key words: Meloidogyne javanica, Meloidogyne incognita,* nematophagous fungus, biocontrol.

Nematophagous fungi have been tested for biological control of plant parasitic nematodes for almost 50 years (1,12). Different species of nematode-trapping fungi have been used in most of these investigations, and thus far no consistent, positive results have been obtained. Encouraging results have been obtained, however, with nematode egg and cyst parasitizing fungi. Endoparasitic fungi which infect nematodes with their conidia have been suggested as possible biocontrol agents, although very little is known about their biology and isolation in pure culture (2). A preliminary evaluation of the effects of the endoparasitic fungus *Hirsutella rhossiliensis* on *Criconemella xenoplax* in greenhouse trials indicated that the fungus reduced nematode populations (3).

Since most endoparasitic fungi are obligate parasites, it is usually difficult to produce large amounts of propagules. An exception is the endoparasitic fungus *Meria coniospora* which grows fairly well and produces an abundance of conidia on both infected nematodes and artificial substrates. Furthermore, this fungus effectively destroys nematodes in soil (5). *M. coniospora* has been used as a model to study interactions between fungi and nematodes, including ultrastructure (10,14), production of antibiotics (1), attraction of nematodes to the fungus, and specificity of conidial adhesion to nematodes (6–10). The strain of *M. coniospora* used in the present studies is very aggressive; 15 of 17 nematode species tested, including *Meloidogyne javanica* and *M. incognita,* were attacked (7). These data suggest that *M. coniospora* is a promising candidate for use in biological control of phytonematodes.

Our objective was to determine the effect of *M. coniospora* on gall formation induced by *M. javanica* and *M. incognita* on tomato in the greenhouse.

## Materials and Methods

*Meria coniospora* Dreschler (CBS 615.82) was cultured on diluted cornmeal agar (CMA 1:10, 1.5% agar) in petri plates. Conidia were collected by flooding plates with sterile water.

*Panagrellus redivivus* (L.) Goodey were from cultures in axenic medium containing hemiglobin (13). The *Meloidogyne javanica* (Treub) Chitwood were provided by Dr. M. Harrison, Cornell University, Ithaca, New York; *Meloidogyne incognita* (Kofoid and White) Chitwood were provided by Dr. M. McClure, University of Arizona, Tucson, Arizona.

Twenty-day-old seedling tomatoes (*Lycopersicon esculentum* Mill. cv. Tiny Tim) were planted in pots containing 250 $cm^3$ steam sterilized commercial potting soil (Terra-lite redi).

The efficacy of the fungus to control *M. javanica* and *M. incognita* was tested in two ways. In the first experimental series, a 1-ml *M. coniospora* conidia suspension was dispersed with a syringe into pots at concentrations of $10^1$ to $10^7$ conidia per 8-cm-d pot. Potted plants without fungal inoculum served as controls. After 24 hours, a sus-

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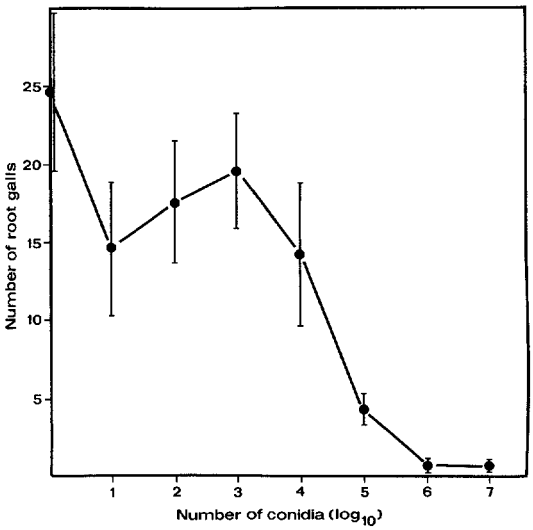


FIG. 1. Effect of different dosages of conidia of *Meria coniospora* on root galling of tomato by 5,000 *Meloidogyne javanica* eggs. Each point is the mean of 10 replicates, and vertical bars represent standard error.

pension of 5,000 *M. javanica* eggs in 1 ml water was added to four depressions (0.5 × 2.5 cm) in the soil of each pot. Each treatment was replicated 10 times.

In the second experimental series, fungus inoculation was by vermiform *P. redivivus* infected with *M. coniospora* (8) at 10, 100, and 1,000 infected nematodes per pot. Controls were pots without nematode-containing fungal inoculum, some treated with aldicarb (Temik 15 G) at 15 mg a.i. per pot, and some not treated. Each treatment was replicated 10 times. These trials were repeated twice with similar results, except that in one trial root-knot infection was very low. Results of the second trial are presented.

A third experiment evaluated the effects on tomato root knot of *M. coniospora* alone ($3.8 \times 10^6$ conidia per pot), *M. coniospora* carried in 150 infected *P. redivivus*, aldicarb (20 mg a.i. per pot), and nontreated plants in both sterile and nonsterile soil. A suspension of 20,000 *M. incognita* eggs in water was added to each pot. Each treatment was replicated 10 times.

All experiments were performed in the greenhouse at ambient temperatures of 30–35 C. The experiments were terminated 60 days following inoculation, and the number of root galls was recorded. Air dry weights were recorded for the root systems and plant shoots. The means and standard errors for each treatment were calculated, and the data were tested statistically using analysis of variance.

TABLE 1. *Meloidogyne javanica* galling of tomato as affected by *Meria coniospora* added to soil via infected *Panagrellus redivivus* compared with application of aldicarb, replicated 10 times.*

| Treatment | Number of *M. coniospora* infected *P. redivivus* | Galls per root system† |
|---|---|---|
| *M. coniospora* + *P. redivivus* | 10 | 18.8 ± 3.0 |
| | 100 | 5.2 ± 2.1** |
| | 1,000 | 2.7 ± 1.2** |
| Aldicarb (15 mg a.i./ 250 $cm^3$ soil) | 0 | 0.7 ± 0.2** |
| Nontreated | 0 | 21.6 ± 4.1 |

* *M. javanica* inoculation was 5,000 eggs per pot.
† Data given as the mean ± standard error.
** Indicates a difference from the nontreated which is significant at the 1% level.

## RESULTS

Highly significant reductions in galling of tomato roots resulted from concentrations of $10^5$ or greater of *M. coniospora* conidia added to soil in Experiment 1 (Fig. 1). In Experiment 2, as few as 100 *M. coniospora*-infected *P. redivivus* gave significant control of *M. javanica* on tomato (Table 1). Direct comparison indicated that the treatment with *M. coniospora*-infected *P. redivivus* was more effective in reducing root-knot galling than the fungus alone in nonsterile soil (Table 2). In both *Meria-Panagrellus* experiments (Experiments 2 and 3), control levels utilizing the fungus–nematode combination were lower than those achieved with aldicarb.

Dry weights of roots and shoots were highly variable, and no significant differences occurred among treatments in any experiments.

## DISCUSSION

Our findings encourage further evaluation of *M. coniospora* for the control of plant parasitic nematodes. Planned research will appraise the effectiveness of *M. coniospora* against tomato root knot in microplot trials in the greenhouse. Since microplot experiments require large amounts of *M. coniospora* inoculum, preliminary trials designed to enhance inoculum production have been run in liquid shake culture with a malt extract substrate. *M. coniospora* concentra-

TABLE 2. Effect of *Meria coniospora* on galling of tomato by *Meloidogyne incognita*, replicated 10 times.*

| Treatment | Galls per root system† | |
|---|---|---|
| | Sterilized soil | Nonsterile soil |
| *M. coniospora* ($3.8 \times 10^6$ conidia) | 1.5 ± 0.4** | 3.1 ± 0.3** |
| *M. coniospora*-infected *P. redivivus* (150 nematodes) | 1.2 ± 0.4** | 1.4 ± 0.5** |
| Aldicarb (20 mg a.i./250 $cm^3$ soil) | | 0.5 ± 0.2** |
| Nontreated | 9.5 ± 1.0 | 11.0 ± 0.8 |

* *M. incognita* inoculation was 20,000 eggs.
† Data given as the mean ± standard error.
** Indicates a difference from the nontreated which is significant at the 1% level.

tions of $10^9$ conidia/ml of culture medium were attained in these trials (H.-B. Jansson, unpubl.). These results indicate that culture systems designed to produce large batches of *M. coniospora* conidia are feasible.

In the experiments utilizing two methods of introducing *M. coniospora* to soil (conidia alone as compared to *Meria*-infected nematodes), there were no differences between the methods in sterilized soil. In nonsterile soil there was a somewhat decreased ability to reduce root galls with the fungus alone, indicating a possible involvement of fungistatic properties in the soil. Fungistatic effects have been shown, for instance, for nematode-trapping fungi (11) and endoparasitic species in the genus *Nematoctonus* (4). In contrast to the latter fungi, the conidia of which apparently were introduced to soil at a stage lacking adhesive processes, *M. coniospora* were inoculated at about 50% mature. Mature *M. coniospora* conidia have an adhesive bud which is necessary for infection of nematodes in the soil. This may explain the low fungistatic effect observed in our experiment. The fact that different soils show different degrees of fungistasis may also be of importance.

The use of infected nematodes to introduce nematophagous fungi to soil was suggested by Giuma and Cooke (4), but the technique was never tested. A similar approach to the biological control of root-knot nematodes was reported by Stirling and Wachtel (15). In the latter trials, second-stage juveniles of *M. javanica* infected with *Bacillus penetrans* were used to introduce the bacterium to the soil. We speculate that nematode carriers of the type used in this study could give the fungus a needed edge, thus enabling the fungus to become established in the rhizosphere. Certainly the approach receives support from the positive results reported here, clearly indicating that further research is warranted.

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