Density-dependence and host-specificity of the nematode-trapping fungus *Monacrosporium ellipsosporum*

Jerome T. GASPARD and R. MANKAU

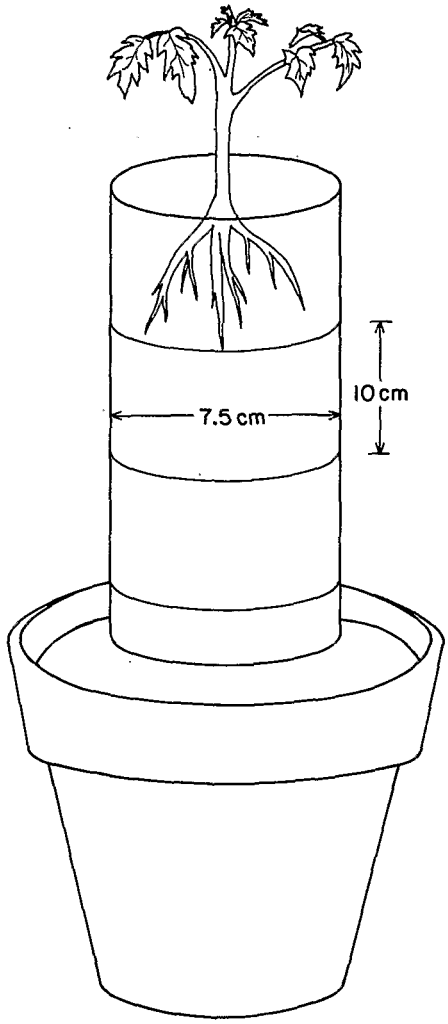
Department of Nematology, University of California, Riverside, CA 92521, USA.

SUMMARY

The infection rate of *Meloidogyne incognita* juveniles was reduced by more than 90 % following migration through soil infested with the nematode-trapping fungus, *Monacrosporium ellipsosporum* to tomato roots. *M. ellipsosporum* reduced the number of

suggests that nematode mortality is dependent on the density of sticky knobs and on the distance that nematodes travel through trap-infested soil. Plant-parasitic nematodes such as *Meloidogyne* spp. are capable of migrating considerable distances through soil (Prot & Van Gundy, 1981). Although this relationship suggests density dependence, nematode numbers often increase after the addition of NTF to soil (Cook, 1962; 1968). It has been assumed that NTF traps are nonspecific and adhere to any nematode that contacts them (Jansson & Nordbring-Hertz, 1980; Rosenzweig, Premachandran & Pramer, 1985). The adhesion phenomenon in at least two NTF, *Arthrobotrys oligospora* Fres. and *Dactylaria candida* Nees ex Pers. has been linked to a lectin (Nordbring-Hertz, Firman & Mattiasson, 1981; 1982). Increases in nematode densities after the addition of NTF could result from selective survival and reproduction of nematodes resistant to capture.

The importance of *M. ellipsosporum* inoculum density and the distance traveled by *Meloidogyne incognita* (Kofoid & White) Chitwood, on nematode mortality were tested in this investigation. In addition, the traps of *M. ellipsosporum* were tested for lectin-mediated host-specificity.



Materials and methods

M. ellipsosporum (ME) was cultured on V 8 broth medium (200 ml V 8® juice, 800 ml water, 5.0 g $CaCO_3$) for seven days on an orbital shaker. ME infested soil consisted of 50 ml of the fungal suspension (approximately 135 mg dry wt in the form of mycelial fragments) mixed with each L/soil (pasteurized loamy sand). Soil and fungus were mixed in a V-shell mixer for 10 minutes. Three to four days were allowed for trap forma-

randomized on a greenhouse bench. After twelve days, the sections were separated and the roots in each of the 10 cm sections were washed free of soil and stained. Treatments were replicated seven times (Experiment 2).

Approximately 750 J2 in suspension were added and covered with 7.5, 15.0, 22.5, or 30.0 cm of soil, respect-

tylenchus sp., *Iotonchus brachylaimus* (Cobb) Andrássy, *Longidorus africanus* Merny, *Meloidogyne incognita* (Kofoid & White) Chitwood, *Mesodorylaimus* sp., *Paratrichodorus minor* (Colbran) Siddiqi, *Pratylenchus scribneri* Steiner, *Seinura oxuris* (Paesler) Goodey, and *Tylenchulus semipenetrans* Cobb. *C. xenoplax* sp., *Helico-*

Table 1

Meloidogyne incognita in tomato roots at various depths in soil columns infested with *Monacrosporium ellipsosporum* or uninfested twelve days after adding 1 500 juveniles at a depth of 30 cm

Depth (cm)	*ME*[a]	*Control*[b]
0-10	157 (74 %)	546* (71 %)
10-20	32 (15 %)	108* (14 %)

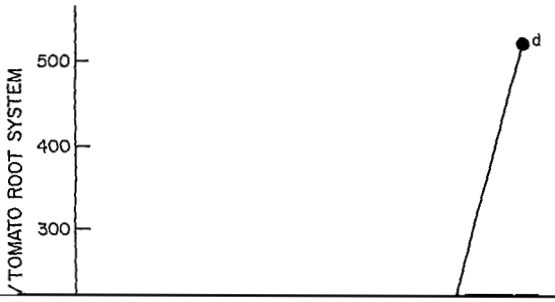


Table 3

Specificity of binding to the sticky knobs of *Monacrosporium ellipsosporum* to sixteen species of nematodes

Nematodes tested	*% nematodes trapped**
Adenophorea	
Dorylaimida	
Longidorus africanus	0 a
Mesodorylaimus sp.	0 a
Paratrichodorus minor	0 a
Xiphinema americanum	0 a
Mononchida	
Iotonchus brachylaimus	8 a
Secernentea	
Rhabditida	
Acrobeloides sp.	100 c
Panagrellus redivivus	100 c
Aphelenchida	
Aphelenchoides sp.	100 c
Aphelenchus avenae	100 c
Seinura oxuris	100 c
Diplogasterida	
Diplenteron sp. (larvae)	100 c
(adults)	0 a
Tylenchida	
Criconemella xenoplax	88 b
Helicotylenchus sp.	92 bc
Meloidogyne incognita	100 c
Pratylenchus scribneri	100 c
Tylenchulus semipenetrans	100 c

* = At least 50 nematodes were tested of each species. Observations sharing the same letter are not statistically different (P = 0.05).

africanus, Mesodorylaimus sp., and *Diplenteron* sp. adults did not adhere to the sticky knobs. *I. brachylaimus,* rarely adhered to knobs. All other nematodes tested readily adhered to ME.

Discussion

Density of trapping organs, and to a lesser extent the distance *M. incognita* juveniles migrated were important factors in nematode survival and root penetration. Capture of juveniles in ME infested soil reduced root

1981). Experiment 2 indicated that ME did not alter the migration behavior of J2. In both the control and the ME infested soil, root penetration occurred primarily in the top 10 cm of soil. Those juveniles in the top 10 cm of the soil columns migrated through at least 20 cm of trap-infested soil to locate a suitable infection site. Although the total number of J2 penetrating roots was reduced in ME soil, the distribution by depth of penetration was similar, suggesting that the proportion of nematodes captured in each 10 cm section was similar.

Varying the distance J2 traveled through soil in slightly influenced root penetration. J2 applied 7.5 cm from the soil surface of ME infested soil made significantly more successful penetrations than those applied further from the roots. The J2 added to control soil were not affected by the depth of addition; root penetration occurred to the same extent or increased at lower depths. Although the nematodes were added at varying depths and migrated up the columns, the tomato roots also grew toward the nematodes as they were migrating; twelve days after planting, tomato roots had reached the bottom of the soil columns. Therefore, the actual distance the nematodes had to travel to enter roots did not correspond to the depth of application and may have been responsible for the discrepancy between the expected and actual penetration of J2 in roots.

Decreasing the inoculum density of ME by serial dilution increased root penetration by J2. At the highest inoculum density, penetration was virtually blocked. At 50 % and 25 % of that density penetration increased but was not different from the 100 % level. Each subsequent dilution level and the uninfested soil had increased penetration. The increase in successful root penetrations by J2 agreed well with the reduction of trap density of ME infested soil from the soil dilutions, as inoculum density of ME increased, the rate of root-knot penetration decreased.

A density and motility dependent relationship is proposed to explain these experimental results. The traps of ME are passive in action. They are, in many ways, analogous to land mines in a mine field. Movement of J2 to these traps is required to initiate parasitism. Although traps of some NTF are attractive to nematodes (Field & Webster, 1977; Jansson & Nordbring-Hertz, 1979), attraction of J2 to the sticky knobs of ME has not been observed (Mankau & Wu, 1985).

Suppression of nematode adhesion to the sticky knobs of ME by flooding the knobs with specific sugars is indirect evidence of lectin involvement. Presumably the

of this study show specificity that falls along taxonomic lines. Nematodes belonging to the class Secernentea were generally captured, while those of the Adenophorea were not. This may reflect fundamental differences in the cuticular structure of the two classes of nematodes (Spiegel, Cohn & Spiegel, 1982). In addition to taxonomic specificity, binding also was stage-specific in the nematode *Diplenteron* sp. Stage-specific binding has also been reported for the binding of *Pasteuria penetrans* spores to the cuticle of root-knot nematode. *P. penetrans* spores bind to juveniles but not adult males of *M. incognita* (Mankau, 1980). These results suggest ME is not a candidate for the biological control of those nematodes which are resistant to this lectin-like interaction and may partially explain why total nematode numbers sometime increase after the addition of NTF to soil.

References

Barker, K. R. (1978). Determining population responses to control agents. In : *Methods for evaluating plant fungicides, nematicides and bacteriocides.* St. Paul, MN, USA, Amer. phytopathol. Soc. : 114-127.

Barron, G. L. (1977). *Nematode-destroying fungi.* Topics in mycobiology No. 1. Guelph, Canada, Can. Biol. Publ. Ltd., 140 p.

Kocourek, J. & Horesjsi, V. (1983). A note on the recent term " lectin ". In : Bog-Hansen, T. C., & Spengler, G. A. (Eds). *Lectins : Biology, Biochemistry and Clinical Biochemistry, Vol. 3,* Berlin, Walter de Grayter : 3-5.

Mankau, R. (1980). Biocontrol : Fungi as nematode control agents. *J. Nematol.,* 12 : 244-252.

Mankau, R. (1980). Biological control of nematode pests by natural enemies. *Ann. Rev. Phytopathol.,* 18 : 415-440.

Mankau, R. & Wu, X. Y. (1985). Effects of the nematode-trapping fungus, *Monacrosporium ellipsosporium* on *Meloidogyne incognita* populations in field soil. *Revue Nématol.,* 8 : 149-153.

McClure, M. & Zuckerman, B. M. (1982). Localization of cuticular binding sites of concanavalin A on *Caenorhabditis elegans* and *Meloidogyne incognita. J. Nematol.,* 14 : 39-44.

Nordbring-Hertz, B. (1973). Peptide-induced morphogenesis in the nematode-trapping fungus *Arthrobotrys oligospora. Physiol. Plant.,* 29 : 223-233.

Nordbring-Hertz, B., Firman, E. & Mattiasson, B. (1981). Host-micro-organisms interaction : Developmentally regulated lectin-mediated capture of nematodes by nematode-trapping fungi. In : Bog-Hansen, T. C. (Ed.). *Lectins : Biology, Biochemistry and Clinical Biochemistry, Vol. 1.* Berlin, Walter de Grayter : 43-50.

Nordbring-Hertz, B., Firman, E. & Mattiasson, B. (1982). A recognition mechanism in the adhesion of nematodes to nematode trapping-fungi. In : Bog-Hansen, T. C., & Spengler, G. A. (Eds). *Lectins : Biology, Biochemistry and*