INTERACTION OF TOBACCO ETCH VIRUS AND THE ROOT-KNOT NEMATODE, MELOIDOGYNE INCognita IN CHILE PEPPER, CAPSICUM FRutescens

by
Stephen Robert Koenning

A Thesis Submitted to the Faculty of the DEPARTMENT OF PLANT PATHOLOGY
In Partial Fulfillment of the Requirements For the Degree of MASTER OF SCIENCE In the Graduate College THE UNIVERSITY OF ARIZONA

1979
STATEMENT BY AUTHOR

This thesis has been submitted in partial fulfillment of requirements for an advanced degree at The University of Arizona and is deposited in the University Library to be made available to borrowers under rules of the Library.

Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgment of source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the Graduate College when in his judgment the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

SIGNED: [Signature]

APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:

[Signature]

MICHAEL A. McCLURE
Professor of Plant Pathology

Date: 14 Nov 79
ACKNOWLEDGMENTS

I wish to thank Dr. M. A. McClure for his assistance and encouragement in all aspects of the research for and preparation of this thesis, and for his personal help and generosity during the period of my studies at The University of Arizona.

Thanks are due to Dr. R. B. Hine and Dr. M. R. Nelson for their critical reading of the manuscript. Thanks are also extended to Ray Wheeler for his help and patience in teaching me electron microscopy and to Larry Stowell for his assistance with the statistics in this research.

Finally I want to thank Diana for her support and encouragement.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIST OF ILLUSTRATIONS</td>
<td>v</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>vii</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>viii</td>
</tr>
<tr>
<td>INTRODUCTION AND LITERATURE REVIEW</td>
<td>1</td>
</tr>
<tr>
<td>Research Objectives</td>
<td>3</td>
</tr>
<tr>
<td>MATERIALS AND METHODS</td>
<td>5</td>
</tr>
<tr>
<td>Plants for Reproductive Studies</td>
<td>5</td>
</tr>
<tr>
<td>Plants for Electron Microscopy</td>
<td>7</td>
</tr>
<tr>
<td>Electron Microscopy</td>
<td>10</td>
</tr>
<tr>
<td>RESULTS</td>
<td>11</td>
</tr>
<tr>
<td>Influence of Tobacco Etch Virus on Nematode Reproduction</td>
<td>11</td>
</tr>
<tr>
<td>Electron Microscopy of Syncytia</td>
<td>11</td>
</tr>
<tr>
<td>DISCUSSION</td>
<td>26</td>
</tr>
<tr>
<td>Control Aspects</td>
<td>28</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>30</td>
</tr>
</tbody>
</table>
### LIST OF ILLUSTRATIONS

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Chromatography tanks containing chile pepper plants for electron microscopy</td>
<td>9</td>
</tr>
<tr>
<td>2.</td>
<td>Effect of inoculation of chile pepper plants with tobacco etch virus on the mean number of eggs produced by <em>Meloidogyne incognita</em></td>
<td>12</td>
</tr>
<tr>
<td>3.</td>
<td>Tobacco etch virus particles (V) in a syncytium induced by <em>Meloidogyne incognita</em> in chile pepper (X 132,500)</td>
<td>14</td>
</tr>
<tr>
<td>4.</td>
<td>Tobacco etch virus particles (V) in a syncytium induced by <em>Meloidogyne incognita</em> in pepper plants (X 66,250)</td>
<td>15</td>
</tr>
<tr>
<td>5.</td>
<td>Pinwheel inclusions (Pw) of tobacco etch virus in a syncytium induced by <em>Meloidogyne incognita</em> in pepper plants (X 66,250)</td>
<td>17</td>
</tr>
<tr>
<td>6.</td>
<td>Pinwheel inclusions (Pw) of tobacco etch virus surrounded by cell wall material (Cw) in a syncytium induced by <em>Meloidogyne incognita</em> in chile pepper (X 79,500)</td>
<td>18</td>
</tr>
<tr>
<td>7.</td>
<td>Pinwheel inclusions (Pw) of pepper mottle virus in a syncytium induced by <em>Meloidogyne incognita</em> in chile pepper (X 39,500)</td>
<td>19</td>
</tr>
<tr>
<td>8.</td>
<td>Pinwheel inclusions (Pw) and virus particles (V) of pepper mottle virus in a syncytium induced by <em>Meloidogyne incognita</em> in chile pepper (X 265,000)</td>
<td>20</td>
</tr>
<tr>
<td>9.</td>
<td>Pinwheel inclusions (Pw) and virus particles (V) of tobacco etch virus in a syncytium induced by <em>Meloidogyne incognita</em> in chile pepper (X 66,250)</td>
<td>21</td>
</tr>
<tr>
<td>10.</td>
<td>Nuclear inclusions (N inc) of tobacco etch virus in a syncytium induced by <em>Meloidogyne incognita</em> in chile pepper (X 6,750)</td>
<td>22</td>
</tr>
<tr>
<td>Figure</td>
<td>Page</td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>11. Adjacent syncytia induced by <em>Meloidogyne incognita</em> in chile pepper both containing pinwheel inclusions (Pw) of tobacco etch virus (X 7,950)</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>12. Pepper mottle virus particles (V) in a cell adjacent to a syncytium induced by <em>Meloidogyne incognita</em> in chile pepper (X 105,200)</td>
<td>24</td>
<td></td>
</tr>
</tbody>
</table>
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The effect of time of TEV inoculation on nematode reproduction</td>
<td>13</td>
</tr>
</tbody>
</table>
ABSTRACT

Reproduction rates of Meloidogyne incognita were reduced significantly in Chile pepper plants which were previously infected with tobacco etch virus but not in plants inoculated with virus after nematode colonization had occurred.

Syncytia of M. incognita contained virus particles of pepper mottle or tobacco etch viruses as well as tobacco etch nuclear inclusions and pinwheel inclusions typical of each virus when virus inoculation preceded nematode inoculation. Evidence of virus infection was not detected in syncytia from controls or plants inoculated with virus after nematode colonization had occurred.
INTRODUCTION AND LITERATURE REVIEW

Reports dealing with interactions between plant parasitic nematodes and other plant pathogens have dealt primarily with fungal or bacterial pathogens or viruses which are vectored by ectoparasitic nematodes. However, some workers (1, 3, 4, 5, 11, 13, 15, 16) have noted synergistic or antagonistic effects on plant parasitic nematodes in virus infected plants. These workers suggested that virus infection influences the host-parasite relationship in nematode infections.

Virus nematode interactions, either antagonistic or synergistic, may be important factors in pest management strategies. Synergistic interactions might necessitate heavier applications of nematicides while antagonistic interactions might reduce the need for chemical control and be exploited for biological control.

Bird (1) found that Meloidogyne javanica grew more rapidly in tomatoes infected with tobacco mosaic virus. He also reported that while the growth rate of M. javanica was unaffected by tobacco ringspot virus in beans, the number of nematodes penetrating the roots was increased.

Rhyder and Crittenden (11) reported synergism in mixed infections of Meloidogyne incognita acrita and tobacco ringspot virus in soybeans. They noted that the number of
syncytia was increased and there was greater clumping of
nuclei and mitochondria near the nematode's head.

In contrast to these studies, Weischer (15) reported that populations of the foliar nematodes *Aphelenchoides ritzemabosi* and *Ditylenchus dipsaci* were reduced 80 and 89% respectively in tobacco plants infected with tobacco mosaic virus. In a later study (16) with the same nematodes but using different viruses he discovered that the effect of each virus on nematode reproduction was different. He found that in a given host plant one virus could be synergistic while another could be antagonistic toward the nematode. Furthermore, he found one virus could be antagonistic toward one nematode and synergistic to another. Weischer (16) took the view that the interaction is based on changes in host physiology since there was no evidence for direct interaction.

Goswami and Chenulu (3), Goswami and Raychauduri (4), Goswami, Singh, and Verma (5), and Khurana et al. (7) have reported both synergism and antagonism with various hosts, viruses, and root-knot nematode species. Goswami and Chenulu (3) demonstrated that the priority of infection was important in determining the type of interaction in mixed infections of *M. incognita* and tobacco mosaic virus in tomato. When virus inoculation preceded nematode inoculation nematode reproduction was reduced but when
nematode preceded virus, nematode reproduction was increased significantly.

Goswami and Chenulu (3) also conducted histopathological studies of roots from mixed infections. Their results are consistent with those of Rhyder and Crittenden (11). Their studies, however, showed differences in synctia related to the precedence of the pathogen.

Wang (14) reported detecting "pinwheel" inclusions in syncytia induced by Meloidogyne incognita in healthy tomato. He reported that he could not detect virus particles in the syncytia or in surrounding cells.

The literature cited indicates that there is some confusion as to the basis of the interaction in mixed virus/nematode infections. This confusion is due in part to the lack of an electron microscopic examination of syncytia from virus infected plants. Such an examination is required due to the small size of virus particles.

Research Objectives

1. Compare rates of reproduction of M. incognita in tobacco etch virus infected and virus free chile pepper, with emphasis on time of inoculation.

2. Study the cytology of syncytia from tobacco etch virus and pepper mottle virus infected and virus free chile pepper.
3. Compare results of reproduction rate changes with observations on the ultrastructure of syncytia.
MATERIALS AND METHODS

Plants for Reproduction Studies

Meloidogyne incognita larvae were derived from a single egg mass taken from an infected chile pepper (Capsicum frutescens (L.) cv. longum Sandt.) growing in a field previously planted to cotton near Elfrida, Arizona. The nematodes were maintained on chile pepper plants in the greenhouse.

Second stage larvae were obtained by the method of McClure, Kruk, and Misaghi (8). Larvae were collected within 24 h of hatching, were counted using a Peters 1 ml counting slide, and the suspension diluted to 500 larvae/ml. A repeating pipette was used to deliver 20 ml aliquots of the larval suspension to the soil surface around each plant to be inoculated.

Chile pepper plants were grown in 15.2 cm diameter pots containing a mixture of 2 parts 20 mesh crystal silica sand and 1 part of local topsoil. Plants were fertilized with 1/4 teaspoon Osmocote (14/14/14)/pot at 6 and 11 weeks after seeding. Tobacco etch virus (TEV, PV-69, American Type Culture Collection) and pepper mottle virus (PeMV-Azd) were obtained from R. Wheeler (USDA, ARS, Tucson, AZ). TEV was maintained in either Datura stramonium or Capsicum frutescens cv. Anahiem. PeMV was maintained in Capsicum
Capsicum frutescens cv. Agronomico 8. Periodic inoculations of Capsicum frutescens cv. tabasco with tobacco etch virus were made to insure purity and virulence of the virus.

Virus inocula were obtained by grinding infected leaves in a mortar containing .01 M Na-KPO$_4$ buffer pH 7.0 and 600 mesh carborundum. Inoculations were performed by dipping an acid brush into the inoculum and gently brushing a leaf held in the other hand. Two leaves per plant were inoculated and the inoculum washed off after 5 minutes.

Virus inoculations were made five times at seven day intervals to provide five treatments with twelve to fifteen replications/treatment. Two additional plants were inoculated at each interval to serve as controls.

Nematode inoculations were performed fourteen days after the first virus inoculations. Thirteen additional plants were inoculated with nematodes alone to serve as controls.

The total of six treatments provided plants which were inoculated with virus fourteen days prior (V+14), seven days prior (V+7), simultaneously (S), seven days after (V-7), and fourteen days after (V-14) nematode inoculation.

Plants were visually inspected weekly for virus symptoms and compared to controls. Five escapes were detected and removed.
Fifty-four days after nematode inoculations the tops were removed and the roots were dipped and rinsed in a bucket of water to remove adhering soil. The roots were then stored in plastic bags with moist paper towels and placed in a refrigerator at 5°C for two days.

Eggs from each plant were extracted separately. Roots were cut into 2.5 cm pieces and placed in a blender the blades of which were covered with plastic tubing. Enough 1.05% sodium hypochlorite was added to bring the volume to 400 ml. After stirring for five minutes the resulting suspension was poured through a food strainer into a 1000 ml beaker and the volume brought to 400 ml. The eggs were collected in a 500 mesh sieve and washed into a beaker with 50 ml of 2% aqueous formaldehyde. The suspension was transferred to a bottle, sealed, and stored at 5°C until counting.

Eggs were counted with a Peters 1 ml counting slide. Analysis of variance and Duncan's multiple range test of means were used to evaluate the data.

Plants for Electron Microscopy

Chile pepper seeds were surface sterilized for five minutes in 1.05% sodium hypochlorite and rinsed for five minutes in distilled water. The sterilized seeds were placed on germination paper covered on both sides with roasting wrap which had been autoclaved previously (9).
The germination paper with seeds was rolled and placed upright in a 250 ml beaker with 100 ml of sterile distilled water and incubated at 28°C.

After a three week incubation period the plants were maintained in a modified (1/2 strength) Hoagland’s-solution pH 5.5. The plants were supported over 4 liter, glass chromatography tanks containing the Hoagland’s-solution by plexiglass racks (see Fig. 1) five plants/rack and five racks/tank. The solution was aerated by pumping air through a water filter into glass frits placed in each tank. The entire apparatus was contained in a growth chamber at 28°C with 37.16 lux illumination supplied by fluorescent bulbs and a 12 hr cycle of light and dark. Distilled water was added periodically to maintain the solution level just below the plexiglass racks.

Nematode inocula was prepared as mentioned earlier; however, the eggs were surface sterilized for 30 minutes with 0.5% Hibitane (Chlorhexidine acetone) and rinsed with sterile distilled water prior to hatching. Inoculations were performed by the method of McClure and Robertson (9) at the rate of 500 larvae/plant. After a 24 hour incubation period the plants were returned to the chromatography tanks in the growth chamber. Virus inoculations were performed as mentioned earlier. Plants were removed from the chromatography tanks 21 days after nematode inoculation and processed for electron microscopy.
Fig. 1. Chromatography tanks containing chile pepper plants for electron microscopy.
**Electron Microscopy**

Galls to be sectioned were excised in m/15 Na-KPO₄ buffer pH 6.8 and fixed in 3% gluteraldehyde in the same buffer. After 5 washes in buffer at 15 minutes per change the galls were postfixed in 2% osmium tetroxide for 2 hours and washed in buffer 5 more times over a sixty minute period.

Fixed roots were dehydrated with either a graduated ethanolic series at 1 hr/change or a graduated acetone series at 15 min/change. After a gradual infiltration of Spurr's hard or firm, low-viscosity epoxy resin the dehydrated galls were embedded in pure Spurr's resin at 70°C for 24 hours. Control and infected material were processed identically.

Sections of embedded root tissue were cut 400-600 angstroms thick on a LKB Ultratome III ultramicrotome and collected on carbon coated copper grids. Sections were stained with either a 0.5% aqueous uranyl acetate/lead citrate combination or a 1.0% potassium permanganate/lead citrate combination. Sections were examined and photographed with a Hitachi H-500 electron microscope at 75 Kv.
RESULTS

**Influence of Tobacco Etch Virus on Nematode Reproduction**

Reproduction rates of *M. incognita* were affected by virus infection, the magnitude and type of interaction being determined by the priority of infection (Fig. 2).

At the 5% level of significance (Table 1) I found that the treatments fell into three groups: subset 1 which contained only one treatment, V+14, represents a 69.5% reduction in nematode reproduction; subset 2 which contained V+7 and V-14 represents reductions of 36.1 and 13% respectively; subset 3 which shared treatment V-14 with subset 2 contained the control (C) and treatments V-7 and S. Treatment S which represents an 0.8% reduction, V-14 which is a 13% reduction, and V-7 which showed a 14.8% increase did not vary significantly from the control.

**Electron Microscopy of Syncytia**

Ultra thin sections of syncytia viewed in the electron microscope provided evidence for the presence of virus in syncytia from plants infected with either tobacco etch or pepper mottle viruses. The visual evidence consisted of several types: (a) the presence of virus particles in syncytia (Figs. 3, 4); (b) the detection of pinwheel inclusions specific to the particular virus in syncytia.
Fig. 2. Effect of inoculation of chile pepper plants with tobacco etch virus on the mean number of eggs produced by *Meloidogyne incognita*. 
Table 1. The effect of time of TEV inoculation on nematode reproduction — Duncan's multiple range test and mean number of eggs/treatment.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Replications</th>
<th>Mean number of eggs</th>
<th>Subset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>13</td>
<td>553076</td>
<td>3&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Virus 14 days prior</td>
<td>15</td>
<td>168866</td>
<td>1</td>
</tr>
<tr>
<td>Virus 7 days prior</td>
<td>12</td>
<td>353583</td>
<td>2</td>
</tr>
<tr>
<td>Simultaneous inoculation</td>
<td>14</td>
<td>548928</td>
<td>3</td>
</tr>
<tr>
<td>Virus 7 days after</td>
<td>14</td>
<td>635357</td>
<td>3</td>
</tr>
<tr>
<td>Virus 14 days after</td>
<td>11</td>
<td>481363</td>
<td>2&amp;3</td>
</tr>
</tbody>
</table>

<sup>a</sup>Subsets of the same number do not differ significantly at the 5% level of probability.
Fig. 3. Tobacco etch virus particles (V) in a syncytium induced by Meloidogyne incognita in chile pepper (X 132,500).
Fig. 4. Tobacco etch virus particles (V) in a syncytium induced by *Meloidogyne incognita* in pepper plants (X 66,250).
(Figs. 5-11); (c) the detection of nuclear and pinwheel inclusions of tobacco etch virus (Fig. 10) and the detection of virus particles and pinwheel inclusions of both viruses in syncytia (Figs. 8, 9).

Evidence of virus infection of syncytia was encountered infrequently. Only 1/4 of the galls examined contained either virus particles or inclusions.

In tobacco etch infections generally only one syncytium contained evidence of viral presence while adjacent syncytia appeared to be virus free. Pinwheel inclusions were detected in adjacent syncytia only once (Fig. 11). Pepper mottle virus infections, however, differed in that commonly two or three adjacent syncytia contained pinwheel inclusions.

Another difference between pepper mottle and tobacco etch virus infections was the presence of virus particles in cells adjacent to the syncytia in tissue infected with pepper mottle virus (Fig. 12). In all galls examined only those in which tobacco etch virus inoculation preceded nematode inoculations was evidence of virus detected. Pinwheel inclusions or virus particles were never detected in those treatments where nematode inoculation preceded virus inoculation, in simultaneous inoculations or in controls.

The numbers of inclusions found in syncytia were not constant. Furthermore some areas of the syncytium
Fig. 5. Pinwheel inclusions (Pw) of tobacco etch virus in a syncytium induced by Meloidogyne incognita in pepper plants (X 66,250).
Fig. 6. Pinwheel inclusions (Pw) of tobacco etch virus surrounded by cell wall material (Cw) in a syncytium induced by *Meloidogyne incognita* in chile pepper (X 79,500).
Fig. 7. Pinwheel inclusions (Pw) of pepper mottle virus in a syncytium induced by *Meloidogyne incognita* in chile pepper (X 39,500).
Fig. 8. Pinwheel inclusions (Pw) and virus particles (V) of pepper mottle virus in a syncytium induced by *Meloidogyne incognita* in chile pepper (X 265,000).
Fig. 9. Pinwheel inclusions (Pw) and virus particles (V) of tobacco etch virus in a syncytium induced by Meloidogyne incognita in chile pepper (X 66,250).
Fig. 10. Nuclear inclusions (N inc) of tobacco etch virus in a syncytium induced by Meloidogyne incognita in chile pepper (X 6,750).
Fig. 11. Adjacent syncytia induced by *Meloidogyne incognita* in chile pepper both containing pinwheel inclusions (Pw) of tobacco etch virus (X 7,950).
Fig. 12. Pepper mottle virus particles (V) in a cell adjacent to a syncytium induced by *Meloidogyne incognita* in chile pepper (X 105,200).
contained numerous inclusions while other areas had few or none. In two syncytia, tobacco etch pinwheel inclusions were found surrounded by cell wall material (Fig. 6). Only one syncytium was found to contain tobacco etch nuclear inclusions (Fig. 10) although within that syncytium several nuclei contained them.
Reproductive rates of *Meloidogyne incognita* were reduced significantly in chile pepper plants which were previously infected with tobacco etch virus. The degree of antagonism was determined by the length of time between virus and nematode inoculations; the greater the interval, the greater the degree of antagonism.

Although synergism of a significant level was not detected, there was a 14% increase in *M. incognita* reproduction when tobacco etch virus inoculation followed nematode inoculation by seven days.

These results are generally consistent with observations made by Goswami and Chenulu (3) that priority of infection determined the type of interaction in tomato infected with both *M. incognita* and tobacco mosaic virus. Discrepancies between my data and that of Goswami and Chenulu (3) may be due to the different hosts and viruses used.

There are several factors which may be responsible for changes in nematode reproduction in virus infected plants. Some of these factors are: (a) changes in host physiology, (b) changes in host vigor, (c) differential penetration of roots by nematodes, (d) differential nematode growth, (e) changes in root volume, and (f) direct
antagonism. While all of these factors may play a role in the interaction, this report suggests that direct antagonism may be responsible for part of the interaction in mixed virus/nematode infections.

This is the first report of virus inclusions and/or virus particles in syncytia induced by phytoparasitic nematodes. While other workers (3, 11, 13) have reported differences in the histopathology of mixed nematode/virus infections, the value of these studies is limited by the resolving power of the light microscope.

The cytological data presented in this report is consistent with my data on differential nematode reproduction in response to the time of virus infection. Evidence of virus infection (pinwheel inclusions and/or virus particles) of syncytia was found only in those treatments where virus inoculations preceded nematode inoculations.

The presence of pinwheel inclusions without identifiable virus particles is taken as evidence for virus infection of syncytia for several reasons. Firstly, the pinwheel inclusions found in syncytia were typical of each virus used (2). Secondly, pinwheel inclusions were never found in controls which were processed along with infected tissue. And, finally, experimental evidence indicates that pinwheel inclusions are viral in origin (6, 10, 12).

This research, however, is not conclusive since several shortcomings are evident. All syncytia examined
were at approximately the same stage of development (21 days). The number of syncytia and the amount of syncytial tissue examined were prohibitively small due to the limited sampling capacity of electron microscopic technique. The number of syncytia containing evidence of virus infection was also small although this may be due to the low concentration of virus particles typical of potyvirus infections or to the small sample size.

The priority of infection appears to be important in some nematode/virus interactions, but several workers (1, 11, 15, 16) used plants which were infected with virus first and noted synergism. The seemingly conflicting reports in the literature illustrate the difficulties inherent in working with three organisms. Differential susceptibility of the host to either pathogen as well as the physiological state and age of the plant add variables to every experiment.

Control Aspects
There is strong evidence that plant viruses have an effect on nematode reproduction. Although these data are based on pot cultures in greenhouses and not on field studies, I feel the data suggest that there may be practical applications to this research. Changes in nematode reproduction, whether positive or negative, should be considered in pest management strategies.
The possibility exists that plant viruses could be used as biological control agents for phyto nematodes. My research showed that a 69% reduction in *M. incognita* reproductive rates could be achieved and Weischer (16) has demonstrated an 89% reduction in *Ditylenchus dipsaci* in tobacco infected with tobacco mosaic virus. Admittedly these are unacceptable controls since a virulent strain of virus used to control nematodes might cause greater reductions in yields than the nematodes, yet only a handful of plant viruses have been tested as to their effects on phytoparasitic nematodes. Also, different strains of the same virus have not been compared as to their differential effects on nematode populations. Although nematode reproduction was not evaluated in pepper mottle infected chile pepper, the higher percentage of virus infected syncytium in pepper mottle infected plants may represent a higher level of antagonism.

The use of plant viruses as biological control agents for phytoparasitic nematodes is presently unpractical since several criteria would have to be met: (a) minimal effects on the host plant, (b) inability to be transmitted to other susceptible crops, (c) a means to inoculate plants efficiently, (d) a high degree of antagonism toward the nematode, and (e) the ability to produce virus in large quantities. Provided these criteria could be met, effective control of nematodes could be achieved.
REFERENCES


