# EFFECTS OF FALLOW, COVER CROPS, ORGANIC MULCHES, AND FENAMIPHOS ON NEMATODE POPULATIONS, SOIL NUTRIENTS, AND SUBSEQUENT CROP GROWTH[1]

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## ABSTRACT

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Experiments were conducted to test the efficacy of summer cover crops, soil-fallow, organic mulches, and fenamiphos for managing populations of plant-parasitic nematodes; effects on soil nutrients were also measured. Three months of fallow, mulching with clippings of bahiagrass (*Paspalum notatum*) or cowpea (*Vigna unguiculata*), and growth of the cover crops hairy indigo (*Indigofera hirsuta*) and joint vetch (*Aeschynomene americana*) were highly effective for maintaining low populations of *Belonolaimus longicaudatus* and *Meloidogyne incognitga.* Cover crops of a mixed seeding of sorghum-sudangrass hybrid (*Sorghum bicolor* x *S. sudanense*) and sesbania (*Sesbania exaltata*), and a natural growth of weeds consisting mostly of pigweed (*Amaranthus retroflexus*), crabgrass (*Digitaria sanguinalis*), and goosegrass (*Eleusine indica*) increased populations of these nematodes. Growth of snap bean (*Phaseolus vulgaris*) and cucumber (*Cucumis sativus*) was significantly greater following the mulches, fallow, and hairy indigo and joint vetch cover crops than following weeds or sorghum-sudangrass and sesbania. Fenamiphos applied at 7.2 kg ai/ha significantly reduced populations of *B. longicaudatus* and *M. incognita* and increased growth of cucumbers and snap bean following weeds and sorghum-sudangrass plus sesbania, but had no significant effects following fallow, mulching, or hairy indigo and joint vetch cover crops. Organic matter content of the soil was significantly greater after incorporation of bahiagrass and cowpea mulches than in fallowed plots. Potassium and magnesium contents of the soil were significantly less in fallow plots than all of the other treatments.

*Additional key words: Belonolaimus longicaudatus, Meloidogyne incognita, Hoplolaimus galeatus, Paratrichodorus christiei, Indigofera hirsuta, Aeschynomene americana, Sorghum bicolor* x *S. sudanense, Sesbania exaltata, nonchemical control.*

## RESUMEN

Rhoades, H. L., y R. B. Forbes. 1986. Efecto do barbecho, cultivos de cobertura, enmiendas orgánicas y fenamifos sobre las poblaciones de nematodos, los nutrientes del suelo y el crecimiento de cultivos subsiquientes. Nematropica 16:141-151.

Se llevaron a cabo experimentos para evaluar la eficacia de cultivos de cobertura de verano, barbecho, enmiendas orgánicas y fenamifos para el manejo de poblaciones de nematodos fitoparásitos. Se evaluaron también sus efectos sobre los nutrientes del suelo. Tres meses de barbecho, enmiendas con recortes de paja bahía (*Paspalum notatum*) o con *Vigna unguiculata* y los cultivos de cobertura *Indigofera hirsuta* y *Aeschynomene americana* sembrados conjuntamente fueron efectivos en mantener bajas las poblaciones de *Belonolaimus longicaudatus* y *Meloidogyne incognita.* Cobertura de un híbrido de sorgo con paja sudan (*Sorghum bicolor* x *S. sudanense*) mezclado con *Sesbania exaltata* y un barbecho compuesto principalmente de las malezas *Amaranthus retroflexus, Digitaria sanguinalis* y *Eleusine indica* incrementaron las poblaciones de estos nematodos. El crecimiento de vainita (habichuelas) (*Phaseolus vulgaris*) y pepino (*Cucumis sativus*) fue significativamente mayor después de las enmiendas, barbecho, cobertura de *Indigofera hirsuta* con *Aeschynomene americana* que después de las malezas o el sorgo-paja sudan con *Sesbania.* Fenamifos aplicado a 7.2 Kg ia/ha redujo significativamente las poblaciones de *B. longicaudatus* y *M. incognita* e incrementó el crecimiento de pepino y vainita después de las malezas y sorgo-paja sudan más *Sesbania* pero no tuvo efectos significativos después del barbecho, las enmiendas, o las coberturas de *Indigofera hirsuta* con *Aeschynomene americana.* El contenido de materia organica del suelo fue significativamente mayor después de la incorporación de las enmiendas de la paja bahía y *Vigna unguiculata* que después del barbecho. El contenido de potasio y magnesio en el suelo fue significativamente menor en las parcelas en barbecho que en todos los otros tratamientos.

*Palabras claves adicionales: Belonolaimus longicaudatus, Meloidogyne incognita, Hoplolaimus galeatus, Paratrichodorus christiei, Indigofera hirsuta, Aeschynomene americana, Sorghum bicolor* x *S. sudanense, Sesbania exaltata, control no-quimico.*

## INTRODUCTION

Several of the most extensively used soil fumigants have been lost in recent years due to environmental and health problems associated with them, and few new nematicides are currently being registered as replacements. As a result, the use of nonchemical management techniques are being considered more and more for control of plant-parasitic nematodes. One of the most common nonchemical methods used by Florida vegetable growers has been summer fallow. This practice has been found to be effective in reducing populations of plant-parasitic nematodes (1,3,6,7). However, fallow is considered to be destructive to fertility and physical properties of soil (10) and is not normally recommended by soil scientists. Earlier research (4,7) showed that hairy indigo (*Indigofera hirsuta* L.) reduced populations of *Belonolaimus longicaudatus* Rau and *Meloidogyne incognita* (Kofoid and White) Chitwood to the extent that only minimal increases in yields of vegetable crops were obtained when a nematicide was applied after this summer cover crop. Another study showed that joint vetch (*Aeschynomene americana* L.) was not a suitable host for *B. longicaudatus, M. incognita, Dolichodorus heterocephalus* Cobb, and *Hoplolaimus galeatus* (Cobb) Sher (5). Organic mulches applied liberally also reduced injury from *Meloidogyne* spp. in Florida (10). While the reasons for the success of organic mulches are not completely understood, it has been shown that the decomposition of organic matter (OM) causes an increase in the activity of nematode predators and a reduction in populations of root-knot nematodes (2).

The decomposition of rye (*Secale cereale* L.) and timothy (*Phleum pratense* L.) residues release nematicidal factors that are toxic to *M. incognita* and *Pratylenchus penetrans* (Cobb) Chitwood and Oteifa (9). These studies were designed to compare the effects of fallow, cover crops, mulches, and fenamiphos on plant-parasitic nematodes, plant nutrients, and soil OM content of a fine sand soil in central Florida.

## MATERIALS AND METHODS

Two experiments were conducted in 1-$m^2$ microplots made from 2.5-cm x 20-cm boards placed approximately 10 cm into the soil. The soil was Myakka fine sand (92.2% sand, 5.7% silt, and 2.1% clay) naturally infested with the following nematodes: sting, *B. longicaudatus;* root-knot, *M. incognita;* lance, *H. galeatus;* and stubby-root, *Paratrichodorus christiei* (Allen) Siddiqi. The soil between microplots was tilled periodically to prevent growth of weeds that might serve as hosts for nematodes. The experimental design for both experiments was a randomized complete block with five replicates.

### *Experiment 1*

Experiment 1 was conducted during the summer and fall of 1984 and repeated in 1985. For a 3-mo period beginning 1 June of each summer, the following treatments were maintained: 1) bare fallow (periodic hand-tilling to prevent weed growth); 2) a cover crop of natural weed growth consisting primarily of pigweed, *Amaranthus retroflexus* L.; crabgrass, *Digitaria sanguinalis* (L.) Scop.; and goosegrass, *Eleusine indica* (L.) Gaertn.; 3) weeds followed by a preplant treatment with 7.2 kg ai/ha of granular fenamiphos; 4) a mixed seeding of the cover crops, sesbania (*Sesbania exalata* [Raf.] Rydb.) and sorghum-sudangrass hybrid (*Sorghum bicolor* L. x *S. sudanense* [Piper] Stapf.); 5) and 8-cm-deep mulch of bahiagrass (*Paspalum notatum* L.) clippings; and 6) an 8-cm-deep mulch of cowpea (*Virgna unguicuata* [L.] Walp.) foliage clippings. Residual fertilizer from a previous vegetable crop maintained the cover crops during the summer. On 1 September 1984, the weeds and cover crops were cut into small pieces by hand, after which these and the mulches were incorporated into the top 15 cm of soil. The plots were handled similarly in 1985, except that the mulches were removed and not incorporated into the soil. Soil samples of 5 cores (1.9 x 17.5 cm) were taken from each plot on 1 September to determine population densities of ectoparasitic nematodes at the end of the summer treatments. During the first week of October, each plot received 1120 kg/ha of 10-2-8 (NPK) fertilizer and was planted with one row each of 'Harvester' snap bean and 'Poinsett' cucumber. Two weeks after emergence, plants were thinned to 6 cucumbers and 10 snap beans per plot, and fertilized again at the same rate. At 6 wk, the cucumber plants were cut and weighed and the roots dug and indexed for root-knot nematode galling using a rating scale of 1=no galling to 5=severe galling. The snap bean plants were cut and weighed at 8 wk. To determine OM and nutrient content of the soil, samples were taken, as described previously, from the 1984 experiment after termination of summer treatments, but before incorporation of the plant material and mulches, and later after cucumber and snap bean harvest. Available nutrients were determined with double acid (Mehlich) extraction solution: 0.0125 $M$ $H_2SO_4$ in 0.05 $M$ HCl.

*Experiment 2*

Experiment 2, conducted in 1985, was handled similarly to Experiment 1 except that hairy indigo and joint vetch were added as summer cover crop treatments, and only a single mulch treatment comprised of equal parts of bahiagrass and cowpea clippings was included. In addition, each treatment consisted of 'with' or 'without' the nematicide, fenamiphos, which where applied, was added just prior to planting the subsequent vegetable crops. All treatments were begun on 5-6 June 1985 and maintained during the summer months. The cover crops and mulches were removed during the first wk of September, the soil prepared, and snap bean and cucumber seeded and maintained as in Experiment 1. Soil samples were removed prior to planting the vegetables to determine population densities of ectoparasitic nematodes Fenamiphos-treated plots were sampled again 8 wk after treatment. Plants were weighed and the cucumber roots indexed for root-knot nematode galling at 8 wk.

## RESULTS AND DISCUSSION

*Experiment 1*

In 1984, populations of *B. longicaudatus* and *P. christiei* were significantly lower in fallow and mulch plots than in weed and sorghum-sesbania plots (Table 1). Populations of *H. galeatus* were significantly lower in mulch plots, but not fallow plots, than in weed or sorghum-sesbania plots. The application of fenamiphos following weeds significantly reduced populations of *B. longicaudatus* 8 wk after treatment, but had no effects on populations of *H. galeatus* and *P. christiei.* Root-knot galling was significantly less after fallow or mulching than after weeds or sorghum-sesbania. Bean plant growth was significantly greater after both mulches than after fallow, weeds without a nematicide, or sorghum-ses-

Table 1. Effects of fallow, cover crops, mulches, and fenamiphos on nematode populations and subsequent growth of vegetables (1984).

| Treatment | Nematode populations[y] | | | | Plant growth[z] | |
|---|---|---|---|---|---|---|
| | BL | HG | PC | Root-knot index | Beans (g/plant) | Cucumbers (g/plant) |
| Fallow | 2.6 | 93 | 5 | 1.84 | 205 | 115 |
| Natural weeds + fenamiphos | 4.0 | 138 | 49 | 2.48 | 272 | 112 |
| Natural weeds | 45.6 | 154 | 57 | 2.72 | 214 | 98 |
| Sorghum + sesbania mix | 68.8 | 177 | 108 | 3.72 | 190 | 68 |
| Bahiagrass mulch | 0.0 | 77 | 2 | 1.61 | 297 | 164 |
| Cowpea mulch | 0.8 | 68 | 3 | 1.60 | 328 | 155 |
| LSD 0.05 | 22.7 | 72 | 28 | 0.53 | 69 | 36 |

[y]Nematode populations for BL (*Belonolaimus longicaudatus*), HG (*Hoplolaimus galeatus*), and PC (*Paratrichodorus christiei*) are mean numbers extracted from 100 $cm^3$ of soil at the end of summer treatments except for fenamiphos plots which were sampled 8 wk after application. The root-knot index for *Meloidogyne incognita* was determined for cucumber roots at 6 wk based on a rating scale of 1=no galling to 5=severe galling.

[z]Average weight per plant of beans at 8 wk and cucumbers at 6 wk.

bania, but not greater than fenamiphos after weeds. Treating with fenamiphos after weeds increased bean plant growth over that following sorghum-sesbania. Growth of cucumber plants was significantly greater in mulched plots than for all other treatments.

Soil samples taken after the summer treatments, but before incorporation of the plants and mulches, were not significantly different in OM, Ca, or Mg content (Table 2); however, K content was significantly greater following both mulches than in all other treatments, and P was greater following both mulches than in all other treatments except weeds followed by fenamiphos. After residue incorporation, OM content was significantly greater in both mulch treatments than after fallowing. Potassium and Mg contents were significantly lower in fallow than in all other treatments, while P was significantly lower in fallow plots than in all other plots, but weeds. There were no significant differences in OM and soil nutrients following the other treatments.

In 1985, populations of *B. longicaudatus* and *H. galeatus* were again higher in the weed and sorghum-sesbania plots than in the other treatments (Table 3). Galling of cucumber roots was much higher following weeds and sorghum-sesbania than in other treatments. Populations of *P. christiei* were extremely low and significant differences in populations were not found among treatments. Bean plant weights were significantly lower after sorghum-sesbania than after all treatments but weeds. Weights of cucumber plants were also significantly lower following weeds and sorghum-sesbania than other treatments except fallow.

*Experiment 2*

In the second experiment, populations of *B. longicaudatus* were again significantly higher following weeds and sorghum-sesbania than after the other treatments (Table 4). Populations of *H. galeatus* were not significantly different among treatments, but populations of *P. christiei* were significantly greater following sorghum-sesbania. No differences in the low populations of *B. longicaudatus* were detected among treatments 8 wk after application of fenamiphos. As in Experiment 1, treatment with fenamiphos had little effect on *H. galeatus*. Populations of *P. christiei* were not significantly different after application of fenamiphos. Root-knot nematode galling of cucumbers was significantly higher after weeds and sorghum-sesbania than after the other treatments. Applications of fenamiphos significantly reduced galling in all treatments except mulching and were particularly effective following weeds and sorghum-sesbania.

Growth of both snap bean and cucumber following weeds and cucumber following sorghum-sesbania increased with fenamiphos

Table 2. Effects of fallow, summer cover crops, and mulches on soil organic matter and nutrient content (1984).

| Treatment | % Organic matter | | Calcium ppm | | Potassium ppm | | Magnesium ppm | | Phosphorus ppm | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Aug. 30 | Dec. 19 | Aug. 30 | Dec. 19 | Aug. 30 | Dec. 19 | Aug. 30 | Dec. 19 | Aug. 30 | Dec. 19 |
| Fallow | 3.72 | 1.80 | 745 | 642 | 45.2 | 47.0 | 81.8 | 60.8 | 133 | 163 |
| Natural weeds + fenamiphos | 3.25 | 1.96 | 844 | 742 | 44.0 | 84.6 | 108.0 | 99.6 | 143 | 178 |
| Natural weeds | 2.57 | 1.93 | 762 | 688 | 40.6 | 83.2 | 87.4 | 83.4 | 134 | 168 |
| Sorghum + sesbania mix | 3.41 | 1.96 | 752 | 667 | 33.0 | 93.0 | 90.0 | 86.8 | 131 | 181 |
| Bahiagrass mulch | 3.15 | 2.06 | 809 | 680 | 101.6 | 59.0 | 92.6 | 76.4 | 146 | 180 |
| Cowpea mulch | 3.67 | 2.11 | 685 | 661 | 172.4 | 70.4 | 99.4 | 94.8 | 151 | 191 |
| LSD | N.S. | 0.19 | N.S. | 94 | 11.0 | 10.3 | N.S. | 15.0 | 12 | 15 |

Table 3. Effects of fallow, cover crops, mulches, and fenamiphos on nematode populations and subsequent growth of vegetables (1985).

| | Nematode populations[y] | | | | Plant growth[z] | |
|---|---|---|---|---|---|---|
| Treatment | BL | HG | PC | Root-knot index | Beans (g/plant) | Cucumbers (g/plant) |
| Fallow | 9 | 49 | 9 | 1.87 | 109 | 122 |
| Natural weeds + fenamiphos | 34 | 173 | 3 | 1.58 | 130 | 148 |
| Natural weeds | 65 | 187 | 7 | 4.54 | 105 | 67 |
| Sorghum + sesbania mix | 108 | 185 | 10 | 4.62 | 82 | 89 |
| Bahiagrass mulch | 1 | 28 | 4 | 1.97 | 137 | 165 |
| Cowpea mulch | 1 | 30 | 4 | 1.73 | 142 | 266 |
| LSD 0.05 | 76 | 91 | N.S. | 0.48 | 25 | 51 |

[y]Nematode populations for BL (*Belonolaimus longicaudatus*), HG (*Hoplolaimus galeatus*), and PC (*Paratrichodorus christiei*) are mean numbers extracted from 100 $cm^3$ of soil at the end of summer treatments except for fenamiphos plots which were sampled 8 wk after application. The root-knot index for *Meloidogyne incognita* was determined for cucumber roots at 6 wk based on a rating scale of 1=no galling to 5=severe galling.

[z]Average weight per plant of beans at 8 wk and cucumbers at 6 wk.

Table 4. Effects of fallow, cover crops, mulches, and fenamiphos on nematode populations and subsequent growth of vegetables.

| Treatment | Nematode populations[y] BL | | HG | | PC | | Root-knot index | Plant growth[z] Beans (g/plant) | Cucumbers (g/plant) |
|---|---|---|---|---|---|---|---|---|---|
| Fallow | 1 | | 63 | | 1 | | 1.65 | 93 | 117 |
| 〃 + fenamiphos | | 2 | | 31 | | 24 | 1.07 | 100 | 144 |
| Weeds | 44 | | 68 | | 10 | | 3.99 | 42 | 151 |
| 〃 + fenamiphos | | 2 | | 51 | | 6 | 1.85 | 107 | 248 |
| Sorghum + sesbania mix | 41 | | 71 | | 46 | | 4.33 | 89 | 85 |
| 〃 〃 〃 + fenamiphos | | 10 | | 78 | | 8 | 2.33 | 123 | 262 |
| Hairy indigo | 0 | | 18 | | 12 | | 1.97 | 111 | 212 |
| 〃 〃 + fenamiphos | | 0 | | 17 | | 24 | 1.33 | 118 | 221 |
| Joint vetch | 2 | | 24 | | 23 | | 2.13 | 103 | 180 |
| 〃 〃 + fenamiphos | | 1 | | 16 | | 26 | 1.33 | 127 | 180 |
| Mulch | 0 | | 33 | | 1 | | 1.48 | 120 | 170 |
| 〃 + fenamiphos | | 2 | | 42 | | 22 | 1.21 | 104 | 174 |
| LSD 0.05 | 18 | N.S. | N.S. | N.S. | 18 | N.S. | 0.52 | 43 | 50 |

[y]Nematode populations for BL (*Belonolaimus longicaudatus*), HG (*Hoplolaimus galeatus*), and PC (*Paratrichodorus christiei*) are the mean numbers extracted from 100 $cm^3$ of soil at the end of summer treatments except for fenamiphos plots which were sampled 8 wk after application. The root-knot index for *Meloidogyne incognita* was determined for cucumber roots at 8 wk based on a rating scale of 1=no galling to 5=severe galling; data from fenamiphos treated and untreated plots were taken on the same date.

[z]Average weight per plant at 8 wk.

useage. In both instances, *M. incognita* galling and *B. longicaudatus* populations had increased to high levels. There was little or no increase in growth from fenamiphos application after fallow, mulching, and growth of the cover crops hairy indigo and joint vetch, where populations of the nematodes had remained low.

The results of these experiments confirm data obtained in previous experiments on certain cover crops and fallow (7,8). Hairy indigo, joint vetch, and fallow were effective for maintaining low populations of *B. longicaudatus* and *M. incognita* and should be useful in the management of these nematodes. However, the detrimental effects of bare fallow on soil physical properties and loss of nutrients should be considered. Mulching with grass or legume foliage was highly effective in suppressing nematode populations. Improvement of soil physical properties from the addition of OM and an increase in certain plant nutrients would be additional bonuses obtained from mulching.

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