# POTENTIAL FOR MANAGING *MELOIDOGYNE KONAENSIS* ON COFFEE IN HAWAII WITH RESISTANCE AND A NEMATICIDE

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## ABSTRACT

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The goal of this research was to determine if *Meloidogyne konaensis* could be managed with a nematicide and/or with resistant rootstocks. *Coffea arabica* cv. typica selection 'Guatemala' grafted onto *C. dewevrei* stocks was compared to Guatemala and *C. arabica* cv. typica selection '502' grown on their own roots. Whole plots consisted of four trees (rootstock selection), two of which were treated bimonthly with 5.6-ml fenamiphos in 8-L water for two years and two trees were untreated. The Guatemala scions grafted onto *C. dewevrei* roots were more vigorous and gave greater yields than 502 and Guatemala grown on their own roots. The nematicide treated Guatemala and 502 on their own roots grew at a slightly faster rate than those growing in untreated soil. The growth rate of the grafted trees was the same in nematicide treated and untreated soil. Nematode numbers in the soil were greatest in November through January of each year of the experiment. In the first year, numbers of nematodes were decreased by fenamiphos on *C. dewevrei* and 502 roots, but greater on Guatemala. The nematicide decreased the population of the nematode on Guatemala in the second year. The greatest economic benefit was realized with the Guatemala scion grafted onto the moderately resistant *C. dewevrei* roots without nematicide treatment.

*Key words:* chemical control, *Coffea arabica*, *Coffea dewevrei*, coffee, fenamiphos, Kona coffee root-knot nematode, *Meloidogyne konaensis*, nematicide, resistance, rootstocks.

## RESUMEN

Schmitt, D. P., F. Zhang and M. Meisner. 2001. Potencial para el manejo de *Meloidogyne konaensis* en café utilizando resistencia y un nematicida en Hawaii. Nematrópica 31:67-73.

La meta de esta investigación fue determinar la factibilidad del manejo de *Meloidogyne konaensis* a través del uso de portainjertos resistentes y nematicida. Las selecciones 'Guatemala' y '502' (*Coffea arabica* cv. Typica) se injertaron en el patron *Coffea dewevrei* y también se cultivaron a pie franco. Las parcelas consistieron de cuatro árboles (portainjertos seleccionados), dos de los cuales fueron tratados con 5.6 ml de fenamifos en 8-L de agua por un perído de dos años y los otros dos fueron testigos. El cultivar Guatemala injertado en *C. dewevrei* presentó raíces más vigorosas, además, sus rendimientos fueron más altos que los obtenidos por este cultivar a pie franco y que los que los del cultivar 502. Los cultivares Guatemala y 502 plantados a pie franco y tratados con nematicida crecieron más rápido que aquellos sin tratamiento. La tasa de crecimiento de plantas injertadas fue similar, independientemente del tratamiento nematicida. Los nematodos en el suelo alcanzaron los niveles más altos en el período comprendido entre Noviembre y Enero de cada año. En el primer año, el número de nematodos se redujo por el tratamiento con fenamifos en *C. dewevrei* y el cultivar 502, pero aumentaron en Guatemala. El nematicida redujo las poblaciones de nematodo en el cultivar Guatemala en el segundo año. El beneficio económico más alto se obtuvo al cultivar Guatemala injertada sobre *C. dewevrei* sin aplicar nematicida.

*Palabras claves:* café, *Coffea arabica*, *Coffea dewevrei*, control químico, fenamifos, *Meloidogyne konaensis*, nematicida, nematodo agallador del café Kona, porta-injertos, resistencia.

## INTRODUCTION

The coffee growers in the Kona area on the island of Hawaii have been experiencing a decline of their crop since the early 1900s when nematodes were noted as a pest capable of causing serious loss (Smith and Blacow, 1907). The dieback of coffee described in 1935 (Ripperton *et al.*, 1935) very accurately describes the decline known today to be caused by *Meloidogyne konaensis* (Eisenback *et al.*, 1994). Severe "coffee decline" samples diagnosed from 1971 to 1990 by the Plant Disease Clinic at the University of Hawaii also fit the *M. konaensis* syndrome. In response to this decline problem, selected rootstocks were evaluated for resistance to the root-knot nematode present at the Kona Experiment Station, Kainaliu, Hawaii (Ito, pers. comm.).

*Meloidogyne konaensis* is very damaging to coffee and has a wide host range (Zhang and Schmitt, 1994, 1995b). Roots of susceptible plants form small to intermediate size galls in response to infection. Few secondary roots develop. As the root ages, the galled area becomes corky.

The severity of the problem requires a nematode management program. Of the options available, resistant rootstocks will likely be the most effective and economical means of achieving good production in infested fields. Nematicides may serve a role in short-term management. Some nematicides have effectively controlled important species of nematodes on coffee and thus may control *M. konaensis* with the goal of maintaining tree vigor and acceptable yields. Aldicarb kept *Meloidogyne exigua* at "acceptable levels" and gave a yield increase (Calafiori *et al.*, 1988). *Meloidogyne incognita* and *Pratylenchus coffeae* were controlled by several nematicides (Wiryadiputra, 1987). Aldicarb, ethoprop, and carbofuran inhibited hatch of *Meloidogyne exigua* at concentrations greater than 0.1 (g/ml (Huang *et al.*, 1983). At these same concentrations, aldicarb and carbofuran decreased motility and increased mortality. Conversely, in Brazil and India, many of the same nematicides were considered to be ineffective for the control of *Meloidogyne incognita* in the field (Curi *et al.*, 1977; Jaehn, 1984; Jaehn and Rebel, 1984; Kumar, 1988). Similarly, in Guatemala, terbufos was only marginally effective for controlling *Pratylenchus* spp. (Villain *et al.*, 2000).

Coffee rootstocks have been found that have resistance to important species of plant-parasitic nematodes. Kumar (1988) recommends grafting *C. arabica* scions onto *C. canephora* stocks. *C. liberica* and *C. dewevrei* are resistant to *Meloidogyne exigua* (Fazuoli *et al.*, 1977). In a preliminary trial, rootstocks of *C. dewevrei* and *C. purpurea* exhibited moderate resistance to *M. konaensis*, providing a potential means of management (Ito, pers. comm.). It was confirmed that *Coffea arabica* 'Guatemala' scions grafted onto *C. dewevrei* rootstocks maintained relatively low populations of *Meloidogyne konaensis* (Zhang and Schmitt, 1995b). The trees were very vigorous even though some galling occurred (Zhang and Schmitt, 1995b).

The objective of this research was to determine the economic potential of fenamiphos for controlling *Meloidogyne konaensis* and increasing coffee growth and yield of resistant and susceptible rootstocks.

## MATERIALS AND METHODS

The experiment utilized an established coffee rootstock trial naturally infested with *Meloidogyne konaensis* at the Kona Experiment Station (elevation = 426 m) at Kainaliu on the west side of the island of Hawaii in a Honuaulu soil. The soil is a Hydric Dystrandepts, thixotropic over fragmental, isothermic (Ikawa *et al.*, 1985). This soil is a very stony silty clay loam with a bulk density (g/cc) of 0.72 in the 0-20 cm depth and 0.39 in the 21-61 cm depth. The slope of the land varies from 3-6%.

The shoots of these trees were cut at about 50-cm above the ground in 1991 and the nematicide trial was initiated in September 1994 after substantial regrowth of the shoots occurred. Scion-rootstock combinations for this trial were selected based on data from a population dynamics study concluded in 1993 (Zhang and Schmitt, 1995a). From the original 10 treatments, three rootstocks were selected for treatment with fenamiphos based on a ranking of susceptibility and plant vigor. These were *C. arabica* cv. typica selection Guatemala (susceptible), *C. arabica* cv. typica selection '502' (susceptible), and *C. dewevrei* (moderately resistant). The scions of Guatemala and 502 were grown on their own roots, but Guatemala scions were grafted onto *C. dewevrei* rootstocks. Each plot consisted of five trees. Two trees in each plot were drenched with 5.6-ml fenamiphos in 8-L of water bimonthly from September 1994 until September 1996. Two control trees in each plot were treated with 8-L of water. The treatments were replicated four times.

Soil samples for nematode assay were collected from the 15 to 30 cm depth prior to nematicide treatment on September 9, 1994, November 10, 1994, January 5, 1995, May 19, 1995, September 13, 1995, January 24, 1996, and September 3, 1996. Plant shoot height was measured at nematode sampling except for September 3, 1996. Nematodes were extracted from soil using a combination of elutriation (Byrd *et al.*, 1976) and centrifugal flotation (Jenkins, 1964). The total weight of coffee fruit was determined for the 1994 and 1995 crops. Data were analyzed using analysis of variance and linear regression (SAS).

## RESULTS AND DISCUSSION

The Guatemala scions grafted onto *C. dewevrei* were more vigorous and gave greater yields than 502 and Guatemala grown on their own roots. Cultivar 502 was more vigorous than Guatemala (Fig. 1).

The rate of tree growth was relatively constant within treatments (Fig. 1). The slope for the growth rate of the Guatemala scion/*C. dewevrei* grafted trees treated with fenamiphos was 0.116 and it was 0.130 for the untreated grafted trees. The slope of the regression lines for growth rate was

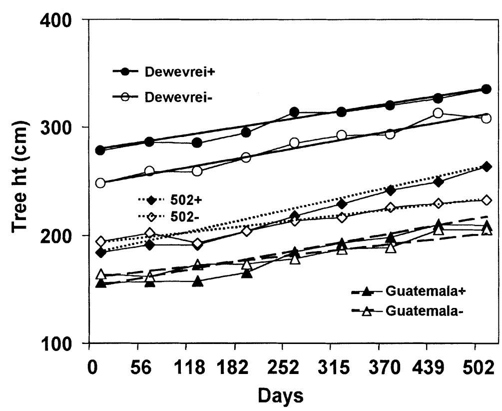


Fig. 1. Coffee tree growth rate from September 1994 to January 1996. Symbols represent actual data; lines are predicted values based on linear regression: *C. dewevrei* rootstock treated with fenamiphos—Y = 277.0 + 0.116X; *C. dewevrei*, untreated—Y = 249.1 + 0.130X; 502 treated with fenamiphos—Y = 178.5 + 0.166X; 502, untreated—Y = 191.4 + 0.085X; *C. arabica* cv. Typica selection Guatemala treated with fenamiphos—Y = 150.1 + 0.127X; *C. arabica* cv. Typica selection Guatemala, untreated—Y = 160.5 + 0.088X.

0.085 and 0.088 for untreated 502 and Guatemala, respectively; and 0.166 and 0.127 for the treated 502 and Guatemala, respectively.

Guatemala scions grafted onto *C. dewevrei* yielded more during the experiment (1994 and 1995) than Guatemala or 502 on their own roots (Fig. 2). Yields of the Guatemala-dewevrei grafted trees increased 2-fold in treated plots and 3.1-fold in the untreated plots from 1994 to 1995. Yields of 502 were small, but increased 2.6-fold from 1994 to 1995 with the nematicide treatment. The untreated 502 trees gave a similar yield in both years. Conversely, overall yields of Guatemala on its own root were reduced by about 45% in the second year. In addition to the decline in yield per tree, three Guatemala trees died during the experiment. Similar results occurred with *C. arabica* grafted onto *C. canephora* in a field infested with *Pratylenchus* spp. in the country of Guatemala (Villain et al, 2000). Yields of cherries were greater on grafted trees than on ungrafted *C. arabica* trees. The ungrafted trees in the country of Guatemala also had higher mortality rates than the grafted trees.

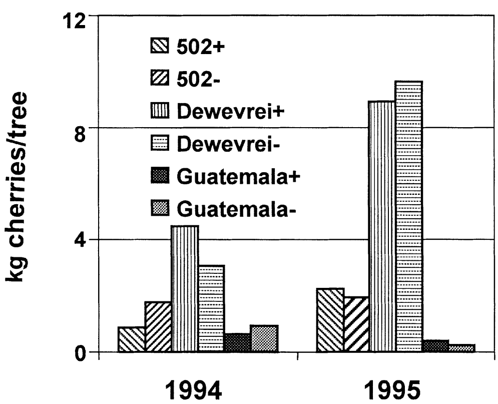


Fig. 2. Yield of coffee fruit at the Kona Experiment Station, Kainaliu, Hawaii, as influenced by rootstock and fenamiphos treatment. (+ indicates treatment with fenamiphos, - indicates no treatment).

A yield benefit was not evident ($P > 0.05$) from the use of fenamiphos even though the growth rate trends of 502 and Guatemala trees treated with the nematicide were slightly greater than in the untreated ones. There are several reports indicating benefits from nematicide treatment. In greenhouse tests, several nematicides enhanced growth of coffee plants infected with *M. incognita* and *P. coffeae* (Echavez and Ayala, 1980). In a 5-year field study, thiadiazinthion reduced root infection of *M. incognita*, and increased plant height and yield (Jaehn and Rebel, 1984). In two different nematicide efficacy trials, significant yield increases occurred even though nematode control did not seem to be high (Jaehn, 1984; Curi *et al.*, 1977). *M. exigua* infected coffee responded with a yield increase following treatment with aldicarb (Calafiori *et al.*, 1988).

Economic gain from pesticide treatment is the basic reason to control nematodes. The cost of the nematicide was greater than the return (Table 1). Since more new growth was occurring in treated plants than in untreated ones, greater yield increases might be expected in subsequent years since the coffee fruit is produced on new growth.

The greatest economic benefit was realized with the Guatemala scion grafted onto the moderately resistant rootstock with or without a nematicide (Table 1). *C. dewevrei* is resistant to *M. exigua* and was not galled by the nematode (Fazuoli and Lordello, 1977). This rootstock was moderately galled by *M. konaensis* in our test, but the root system was still large (data not shown).

Nematode numbers were greatest in November through January of each year (Fig. 3). The numbers were much greater in November 1994 and January 1995 than a year later. The only significant population peak in January 1996 was exhibited on Guatemala roots. The nematicide's effect

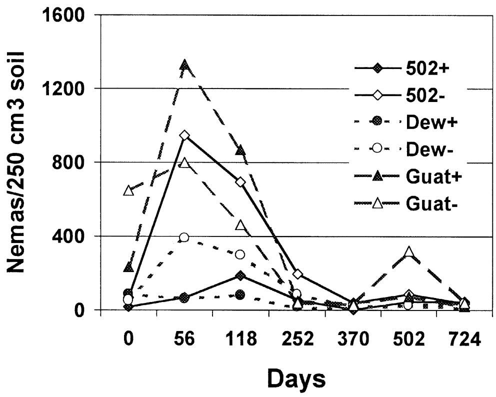


Fig. 3. Population change of *Meloidogyne konaensis* on coffee at the Kona Experiment Station, Kainaliu, Hawaii, from September 9, 1994 to September 3, 1996. (+ indicates treatment with fenamiphos, - indicates no treatment).

could be detected during these population peaks. In the first winter, nematode numbers were lower in the *C. dewevrei* and 502 treatments, but higher on Guatemala after treatment with fenamiphos. A year later, however, numbers on Guatemala were lower on the treated roots. Guatemala roots were so heavily damaged that the nematodes most likely had only a few suitable roots to feed on during the first year of the experiment, whereas the treated roots may have produced a few roots that provided a food base to allow greater reproduction than on the untreated root. In contrast, 502 appears to be more tolerant and *C. dewevrei* is clearly more resistant than Guatemala, thus both of these treatment would react to fenamiphos in a more predictable manner; that is, population reduction soon after treatment. Terbufos affected populations of *Pratylenchus* spp. in Guatemala in only the first year of a 4-year study (Villain *et al.*, 2000).

Considering the overall population trend with highest numbers in the winter, Zhang and Schmitt (1995a) and Serracin and Schmitt (unpubl. Data, 1997-1999) found the opposite with higher numbers occurring in July than in the winter. The population peaks in this present test occurred at a period of the year with the least rainfall (Fig. 4). These population increases probably follow a period of a root growth. In 1994, the heavy rainfall events occurred in August and September, whereas in 1995, heavy rainfall began to occur earlier in the year (June) and continued through September. In 1996, large quantities of rain occurred from June through September. Again, population densities were low. These longer durations with large quantities of precipitation could have set up conditions to encourage nematodes to remain in roots rather than having a tendency to move into the soil. In a study with *M. konaensis* comparing natural rainfall to irrigation at regular intervals to maintain the soil moisture near 33 kPa, similar results were found in which greater numbers were present in the root under the irrigated than with natural precipitation (Serracin and Schmitt, unpubl.). With *M. hapla*, in an experiment using a split-root system, one held at the permanent wilting point and the other irrigated frequently to maintain field capacity (= 33 kPa), no galls developed at the permanent wilting point even though eggs hatched readily; the nematodes did not migrate (Couch and Bloom, 1960). At field capac-

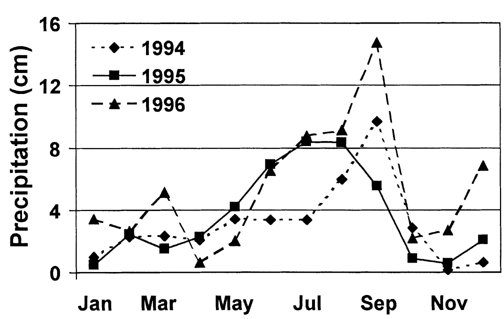


Fig. 4. Precipitation at the Kona Experiment Station, Kainaliu, Hawaii, from January 1, 1994 to December 31, 1996.

Table 1. Economic return per tree and per hectare from the rootstock and nematicide treatments based on $3.57/kg green coffee and 1780 trees per hectare.

| Rootstock | Nematicide | Estimated green coffee[z] (kg/tree) | Return/tree U.S. $ | Return/hectare U.S. $ |
|---|---|---|---|---|
| | | 1994 | | |
| 502 | + | 0.17 | 3.01 | 5 358 |
| 502 | - | 0.35 | 6.23 | 11 089 |
| Dewevrei | + | 0.90 | 15.87 | 28 249 |
| Dewevrei | - | 0.63 | 10.82 | 19 260 |
| Guatemala | + | 0.12 | 2.16 | 3 845 |
| Guatemala | - | 0.19 | 3.25 | 5 785 |
| | | 1995 | | |
| 502 | + | 0.44 | 7.87 | 14 009 |
| 502 | - | 0.38 | 6.76 | 12 033 |
| Dewevrei | + | 1.78 | 31.45 | 55 981 |
| Dewevrei | - | 1.93 | 33.98 | 60 484 |
| Guatemala | + | 0.08 | 1.38 | 2 456 |
| Guatemala | - | 0.05 | 0.88 | 1 566 |

[z]Green coffee is estimated as 20% of cherry weight.

ity, eggs hatched, nematodes migrated, infected, and induced galls. A significant positive correlation of second stage juveniles of *M. exigua* and soil moisture was found with *C. arabica* 'Catuai' (Souza *et al.*, 1998). These different experiments demonstrate the variable effects of soil water. Because of the impact of water on the plant and nematode interaction, management of both organisms is dependent upon utilizing water to maximize plant growth and minimize the nematodes impact.

Villain *et al.* (2000) demonstrated that using a *Pratylenchus* spp. resistant rootstock provided effective control of that nematode and a subsequent economic gain in yield. They also showed that the nematicide benefit was marginal. In the Kona area of Hawaii, nematicides may provide some protection of coffee roots to *M. konaensis*, but grafting onto the resistant rootstock of *C. dewevrei* offers the best single management tool with current technology.

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