Excellent results in the control of false codling moth in field trials using entomopathogenic nematodes

A.P. MALAN[1], S.D. MOORE[2,3]

[1]Department of Conservation Ecology and Entomology, Faculty of AgriSciences, Stellenbosch University;

[2]Citrus Research International; [3]Rhodes University

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SUMMARY

False codling moth (FCM), *Thaumatotibia leucotreta,* is one of the most important insect pests of citrus and potentially other crops in South Africa. The only treatment currently directed towards the soil stages of FCM are entomopathogenic nematodes (EPNs). However, on a very small scale. Laboratory bioassays using orchard soil with *Heterorhabditis bacteriophora* showed that as few as 3 nematodes could kill 50% of the test larvae and 59 nematodes were needed to kill 90% of larvae. In a field trial, 20 IJs/cm^2 of *H. bacteriophora* caused 90% mortality of FCM larvae, immediately after application with some persistent control even after 21 days. With the field application of a second nematode, *H. zealandica,* higher than 80% mortality was obtained using only 5 IJs/cm^2 originally applied and still being active after 35 days. Field trials showed local EPN species to have great potential for control of the soil stages of FCM, with the added possibility of good persistence.

Entomopathogenic nematodes (EPNs), also called insect parasitic nematodes, are effective and safe biocontrol agents against a wide range of pest insects. They occur in all soils and deliver an important ecosystem service as natural suppressors of the soil stages of many pest insects. The infective juvenile (IJ), which is the only free-living stage that occurs in the soil environment is very resistant to adverse conditions in the soil and can survive for several months without feeding. It is this stage that is used for application in insect control. The main interest in EPNs as biological control agents revolves around their ability to seek out their host in hiding places, where they are capable of causing host mortality within two days. In addition, nematodes can be commercially produced, formulated and can be used in combination with chemicals in an integrated pest management system.

False codling moth (FCM), *Thaumatotibia leucotreta,* life stages that could be targeted by using EPNs, include the final-instar larvae, the prepupae, pupae in the cocoon, and the emerging moth. The life cycle of FCM is approximately 25-60 days, of which the soil stages span approximately 14-16 days, depending on the prevailing temperature, which offers a long window period for the use of EPNs.

Very little research on the use of EPNs to control FCM has been published. In a previous study, final-instar larvae were shown to be highly susceptible to all indigenous EPN isolates, while emerging moths could also be infected with nematodes, adding to the long-distance dispersal of nematodes. *Heterorhabditis bacteriophora* was found to be the most frequently encountered EPN in local citrus orchards and therefore the species of choice to be used for the control of FCM.

The main aim of this study was to determine the control potential of EPNs against FCM under field conditions. The effect on FCM mortality directly after application was determined, as well as the field persistence of nematodes for different periods after application.

In the second field trial, the immediate effect of the application of *H. zealandica* at much lower concentrations, and with a longer field exposure resulted in FCM mortality of ≈ 80% being achieved, including

DID YOU KNOW?

EPNs work together with symbiotic bacteria, responsible for killing the insect, and bio-converting the inside of the insect into a food source for itself. The bacteria in turn then serves as a food source for the nematodes. The bacteria causes the infected FCM larva to turn red, seen halfway removed from a soil cocoon below.

DID YOU KNOW?

The soil stage of false codling moth could be 12-16 days depending on temperature, giving a wide window of opportunity to use entomopathogenic nematodes for their control. In the picture infected larvae retrieved from the soil cocoons are shown.

with the lowest concentration of 5 IJ/cm^2. However, no further FCM control was obtained after 21 days (Fig. 2). As *H. zealandica* were applied at low concentrations to a limited area around each treatment tree, it is assumed that in nature, without hosts being available to enable recycling, the IJs would likely dilute through the soil to the normal background levels found in nature. In whole-orchard application, a longer persistence of nematode would be expected. In another South African study, the naturally occurring *H. zealandica* in a citrus orchard in Nelspruit, led to 59% less fruit infestation with FCM, compared to infestation in a citrus block treated with a nematicide (cadusafos) Manrakhan et al., 2011.

In the third trial using 10 IJs/cm^2 for each of the three EPN species, it was found that *S. khoisanae* did not perform well in comparison with the other two species, while *H. bacteriophora* and *H. zealandica* gave comparable results (Fig. 3). Persistence of the applied EPNs was good, showing the best control of FCM by *H. zealandica,* followed by *H. bacteriophora* and then by *S. khoisanae.* After 49 days, control was < 30% for all three species. The higher persistence of the three different species, when applied at lower concentrations, in comparison to the previous two trials, can be ascribed to the application of EPNs to a larger area around the tree. This could have slowed down the horizontal and vertical movement of the nematodes, which would have led to slower dispersal from the application area, as nematodes have the potential to live for several months in soil without a host.

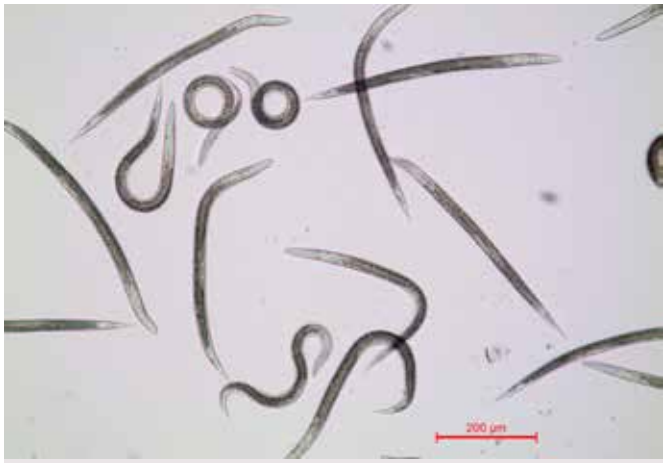
The rapid decline in IJs after application may be in part, due to the presence of the natural enemies of EPNs in the soil, such as fungi and bacteria, some of which have been shown to respond to nematode augmentation in a density-dependent manner. The impact of nematode antagonists can reduce the applied nematode population rapidly. Other research undertaken has shown that relatively little is known about EPN

MAIN FIELD TRIAL RESULTS

TRIAL 1:
Control > 90% of buried FCM larvae, 2 days after application of *H. bacteriophora* and control for up to 14 days.

TRIAL 2:
Control > 80% of FCM larvae, 6 days after application of *H. zealandica* with no further control after 21 days.

TRAIL 3:
Control for *H. bacteriophora* ≈ 80% and for *H. zealandica* ≈ 60% with very good control after 35 days.



This is what your active ingredient would look like through the microscope!

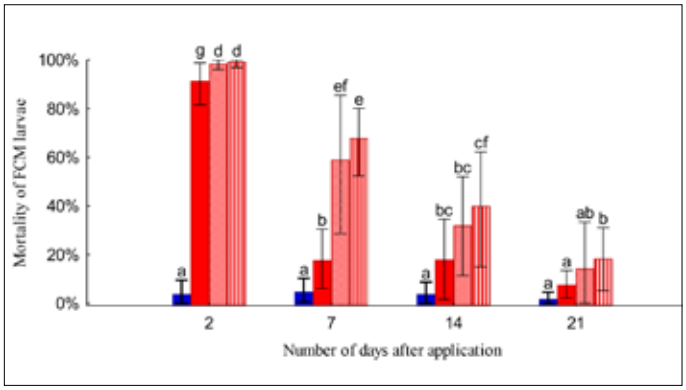


Fig. 1. *Percentage infection of late-instar false codling moth (FCM) larvae after field application of 0 ■, 20 ■, 40 ■ and 80 ■* Heterorhabditis bacteriophora *infective juveniles per cm². Mortality by infection was evaluated after 2, 7, 14, and 21 days.*

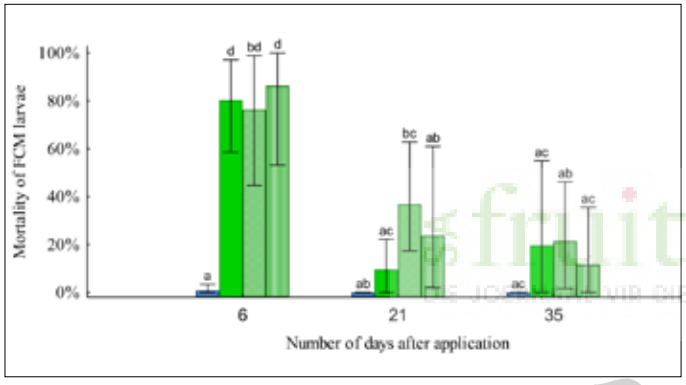
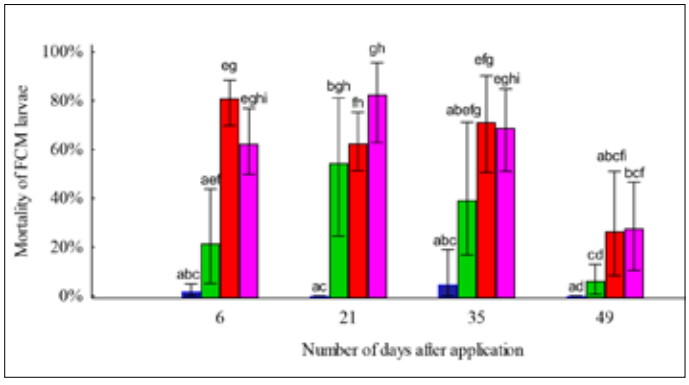


Fig. 2. *Percentage mortality for late-instar false codling moth (FCM) larvae, 7, 21, and 35 days after the inoculation of* Heterorhabditis zealandica *at concentrations of 0 ■, 5 ■, 10 ■ and 20 ■ infective juveniles per cm² in the citrus orchard.*



Trial 3. *Percentage mortality for late-instar false codling moth (FCM) larvae, 6, 21, 35, and 49 days after application of water only ■,* Steinernema khoisanae ■, Heterorhabditis bacteriophora ■ *and* H. zealandica ■ *in a citrus orchard at concentrations of 10 IJs/cm².*

ecology or biology in the field after inundative application. Learning more about the interactions that occur in the soil food web, especially in relation to EPNs, should provide opportunities for improving the biological control of FCM.

The limited amount of research that has been conducted to date on the control of FCM using EPNs indicates that nematodes might well be exceptionally good biological control agents against FCM. However, much research is still required to ensure reliable control in all the different citrus-producing areas of South Africa. In Florida, the use of nematodes on a commercial scale against the citrus root weevil has given better results than chemicals, although it was found that the level of suppression achieved varied greatly. The role of nematodes in the Florida ecosystem, and how indigenous nematodes interact with exotics, as well as with the rest of the biological component of the soil, requires investigation.

Since FCM is a key pest in South Africa, EPNs should be tested for their field efficacy in an IPM system. FCM is an insect with several generations per year, offering year-round availability as a host for EPN, thus increasing the possibility of persistence in citrus orchards. Currently, soil treatment for FCM with EPNs is employed on a very limited scale. There is thus great potential for expanding their use as an additional tool for the reduction of FCM populations in orchards. In addition, EPN is a biological control agent that should be effective against high numbers of host insects, which should facilitate a high level of nematode reproduction, and hence persistent control. The ability to target a host with up to six generations per year, the high susceptibility of FCM to EPNs, and the persistence of the EPNs in the soil after application, as seen in the results obtained in the current study, means that EPNs could play an increasingly important role in the successful control of FCM.

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Additional reading

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