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Field trials for suppression of spruce cone maggots, *Strobilomyia appalachensis*, using entomopathogenic nematodes

Seed orchards provide genetically improved seed for seedling production; black spruce, *Picea mariana*, is a species of choice in tree improvement and reforestation programs in eastern Canada. The cone maggot, *Strobilomyia appalachensis*, feeds within the cones of black spruce and can reduce annual seed production by 30-60%. Development of an effective strategy for suppressing cone maggot populations with entomopathogenic nematodes would provide seed orchard managers with an alternative to systemic insecticides, currently the only practical means of control.

Background

In laboratory studies conducted in moist sand, we found that cone maggot larvae, but not puparia, were susceptible to low concentrations of the entomopathogenic nematodes, *Steinernema carpocapsae* and *S. feltiae*. However, attempts to infect larvae feeding within the cones were unsuccessful. Therefore, our strategy was to infect and kill the majority of mature maggot larvae that drop to the soil in July (after damage has occurred) to reduce the numbers of adult flies emerging the following spring. Maggot larvae leave the cones and drop to the soil in July during periods of rainfall, burrow 2-3 cm into the soil and form puparia in 3-5 days. The entire period of larval drop may last from 2 to 4 weeks. Therefore, to ensure adequate maggot suppression, a sufficient concentration of nematodes must be active in the top layer of soil for a 3- to 4-week period, so that larvae may be infected before they form puparia.

In cooperation with Hart Kunze and Greg Adams of J.D. Irving, Ltd., a field trial was held at the black spruce breeding garden in Sussex, N.B., in July 1992. Application of *S. feltiae* at a rate of 0.5 million nematodes per m^2 infected an average of 86% of maggot larvae that were dropped on the soil immediately after application. However, at 1 or 2 weeks following application the percentage of larvae infected had dropped to only 10-20%

and was not significantly different than that in untreated control plots. We suspected that conditions in the top layer of soil (where the maggot larvae were) may have been too dry to allow sufficient nematode activity and survival.

Therefore, another field trial was planned for 1993, again with the cooperation and assistance of J.D. Irving, Ltd. and Hart Kunze in Sussex, N.B. Our objectives were: 1) to determine whether or not irrigation would improve nematode persistence and percent maggot infection in field applications of nematodes; 2) to compare the persistence and efficacy of *S. feltiae* that had been acclimated to either a fluctuating temperature regime or a constant 6°C, prior to field application; and 3) to monitor for possible effects of nematode applications on the abundance of nontarget soil arthropods.

Project Description

We tested *S. feltiae* strain 27 that had either been stored at 6°C prior to field application ("standard"), or acclimatized to temperatures that fluctuated daily from 12 to 25°C, simulating soil temperatures recorded at the field site in July ("acclimatized"). The intention was to acclimatize the nematodes to the temperature regime they would encounter in the field, and perhaps improve their efficacy and persistence.

Nematodes were applied on the evening of 21 July at a rate of 0.8 million[1] per L water per m^2 using a conventional hydraulic sprayer with a boom adapted for herbiciding tree rows. One half of plots were irrigated at a rate of 1L per m^2 on 4 August, and at a rate of 2L per m^2 on 6, 9, 10, 11, 12, and 13 August, using an hydraulic sprayer. Plots were not irrigated prior to 4 August because we felt that conditions were moist enough from normal rainfall.

Summary of Results

Irrigation significantly increased percent soil moisture but had no effect on percent infection or nematode persistence, so data were pooled. Results were similar to those found in 1992. Percent infection averaged 80% for maggot larvae dropped on the soil immediately after application but fell significantly for larvae dropped on the soil 1 or 2 weeks later. The acclimatized nematodes had significantly greater percent maggot infection (14%) than the standard nematodes (0%) 2 weeks following nematode application but percent infection was still far lower than the desired 80%+. The number of nematodes per gram of soil also declined rapidly following the date of application. At 16 days following nematode application, the numbers of nematodes per g were no different in treated and untreated plots.

Data on the numbers of nontarget arthropods have not been fully analyzed but, so far, the data suggest little measurable impact of the nematode applications. The mean weekly catches of carabids, ants, and spiders in pitfall traps placed in the four treated plots were compared with those in the four untreated plots for 2 weeks prior to and following nematode application and the only significant differences to note were fewer ants trapped in treated rows during the first week after application, and greater numbers of spiders trapped in the rows designated to be treated during the last week before nematodes were applied.

Work planned for 1994 includes field testing of the recently developed solid formulation of entomopathogenic nematodes. These formulations are expected to release nematodes at a gradual rate, depending on the amount of rainfall, and they may prove more persistent than liquid formulations.

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[1] In an operational situation, this concentration would result in about 2 billion infective juveniles (IJs) per ha of total seed orchard because the nematodes need only be applied to a 0.75-m strip along the tree rows, and seed orchards are usually planted in a 3 x 3 m spacing or wider. BIOSYS considers rates of 2.5 - 5 billion IJs per ha to be economically feasible, depending on the crop.