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Glasshouse control of fungus gnats, *Bradysia paupera*, on fuchsias by *Steinernema feltiae*

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Summary – In glasshouse grown fuchsias, *Steinernema feltiae* applied by hydraulic sprayer at 780 000 nematodes/m^2 resulted in a decrease of 92 % in the numbers of *Bradysia paupera* adults emerging from the compost. The nematodes were well distributed in the potted compost and they persisted in the compost over the 64 day experimental period.

Résumé – ***Contrôle par* Steinernema feltiae *du moucheron* Bradysia paupera *sur fuchsias cultivés en serre*** – *Steinernema feltiae* appliqué à l'aide de pulvérisateurs hydrauliques à la dose de 780 000 nématodes/m^2 sur des fuchsias cultivés en serre provoque une diminution de 92 % du nombre des *Bradysia paupera* adultes provenant du compost. Les nématodes se répartissent correctement dans le compost et ont persisté pendant les 64 jours qu'a duré l'expérience.

Key-words : Entomopathogenic nematodes, *Steinernema feltiae*, sciarids, *Bradysia paupera*, glasshouses.

Sciarid flies commonly infest glasshouse ornamentals where they rapidly increase to levels when serious damage may occur. The larvae feed on organic matter, fungi or algae (Freeman, 1983) also on the roots of cuttings and small plants, tunnelling into their stems (Binns, 1973). Sciarid larvae can damage mature plants and are vectors of bacterial and fungal pathogens (Leath & Newton, 1969).

Steinernema feltiae (Steinernematidae), a rhabditid nematode occurring throughout Europe, is mutualistically associated with a bacterium *Xenorhabdus* sp. The nematodes have an infective third stage juvenile (IJ) which can enter the insect host through the mouth, anus or spiracles (Georgis & Hague, 1981; Mráček *et al.*, 1988). IJs are able to survive for long periods in soil at low densities (Kaya, 1991) and are best suited to cryptic environments where insecticides are more difficult to apply. IJs are attracted to excretory products, probably CO_2, of the host larvae (Gaugler *et al.*, 1980), and after entering the insect host, IJs invade the haemocoel where *Xenorhabdus* is released from an œsophageal vesicle causing septicemia and death to the insect host (Poinar & Thomas, 1966). The nematodes feed on the septicemic tissue, reproduce and leave the host as a new generation of IJs when the food reserves in the insect cadaver are depleted. In sciarids *S. feltiae* undergoes only one generation compared to three or more in *Galleria mellonella* (Gouge, unpubl.).

The use of insecticides to control sciarids, particularly in mushroom houses, has resulted in widespread resistance in these insects (White, 1981). Successful control of sciarids with *S. feltiae* has been demonstrated by several authors, e.g. against *Lycoriella mali* in the USA (Nickle & Cantello, 1991) and against *L. auripila* in the UK (Richardson & Grewal, 1991).

The present paper describes experiments in a glasshouse growing fuchsias where *S. feltiae* was applied to control *Bradysia paupera* (Tuomikoski), one of the most common sciarids in UK glasshouses. The distribution and persistence of *S. feltiae* in the potted compost was also investigated.

Materials and methods

The experiment was conducted in a commercial glasshouse growing potted fuchsias where there was a natural infestation of *Bradysia paupera.*

The *S. feltiae* used in this experiment was isolated from woodland soil on the Reading University campus, cultured on *Galleria mellonella* (the greater wax moth), and then formulated by Biosys where it was produced in a fermenter and sent back to the UK in alginate gel preparation (Biosys, isolate 244). The commercial formulation was applied to fuchsias cv. Snow Cap, grown individually in plastic plant pots (8 cm deep, 8 cm diameter) at a rate of 780 000 nematodes/m^2 using a Brinkman hydraulic sprayer, the nematode suspension being flood-irrigated onto the benches of fuchsias. Samples of nematodes were visually examined before and after passage through the sprayer to estimate the effect on nematode viability.

There were 720 pots per bench, four benches were treated with nematodes and four untreated benches received water only. The peat based potting medium was Fisons M2 (+ Phycote 3 kg m^2), pH 4.5, and all pots were top watered daily, the temperature in the glasshouse being maintained at 20-24 °C.

Estimation of sciarid population

The experiment was sampled immediately after treatment and then at 7, 28, 42 and 62 days after the application of the nematodes. Two methods of estimating the sciarid population were used on each sampling date :

(1) Four pots were taken at random, one from each of the treated and one from each of the untreated benches, and caged under muslin in the laboratory. The emerging adults were caught over a period of two weeks on sticky traps hung inside the cages and counted.

(2) Three sticky traps were hung above each glasshouse bench and the number of adult sciarids caught were counted; sticky traps were replaced on each sampling date. Results were expressed as the number of sciarid adults caught on traps hung to cover an area of approximately 240 plants (*ca* 36 m^2).

Distribution of nematodes in pots

On the day of application and at 8, 29, 43 and 64 days after treatment, samples were taken as follows. Three pots were taken at random from each bench and the compost in each pot divided into four equal 2 cm sections from top to bottom of the pot. Each section was placed in a 500 ml plastic container and baited with three *G. mellonella* larvae. After 5 days the *G. mellonella* larvae were removed, dissected in 1/4 strength Ringers solution and the number of developed IJs counted. Three more *G. mellonella* larvae were then added to each sample and the process repeated, baiting being continued until no more IJs entered *G. mellonella* larvae (Fan & Hominick, 1991). This exhaustive baiting technique was used to estimate the number of infective nematodes in the compost.

Gouge (unpubl.) has shown that sciarid adults which crawl on the compost can be infected by *S. feltiae*, therefore the untreated compost was sampled for nematodes with *Galleria* at the end of the experiment.

Results

By visual assessment under the binocular microscope there was no effect on viability of passing *S. feltiae* through a hydraulic sprayer, 95 % of the nematodes being viable 24 h after application. There was a significant decrease (73 %) in the number of flies caught (Fig. 1) using sticky traps suspended over the crop for assessment, but it was also noted that there was a decrease in flies caught on the untreated pots. Caging pots after treatment resulted in a decrease of 93 % in flies emerging by day 64 compared to a 53 % decrease in the untreated pots (Fig. 2).

On the day of application, nematodes were found in the top 4 cm of the pot (Fig. 3). With time, nematodes became distributed throughout the pots. After 29 days there was no significant difference in the numbers in each section of the pots. There was an overall decline in the number of nematodes sampled up to 43 days after

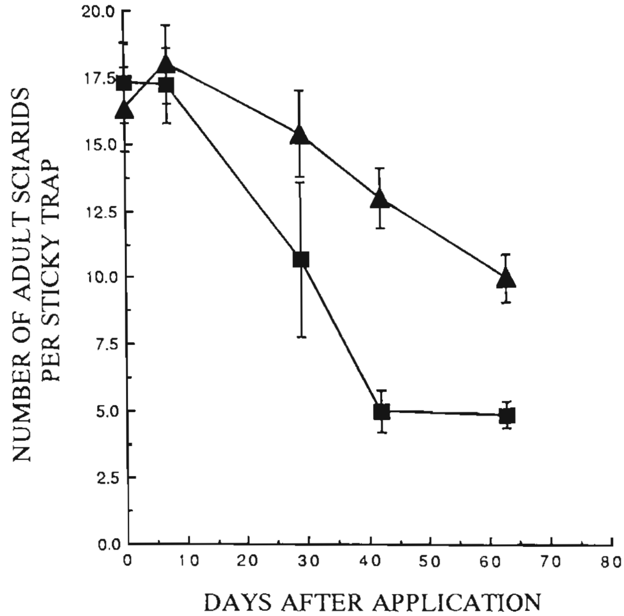

Fig. 1. *The mean number of adult* Bradysia paupera *caught on sticky traps hung above the crop for 64 days, treated (■) and untreated (▲). (Vertical lines are standard errors; three replicates covering 36 m^2 per trap).*

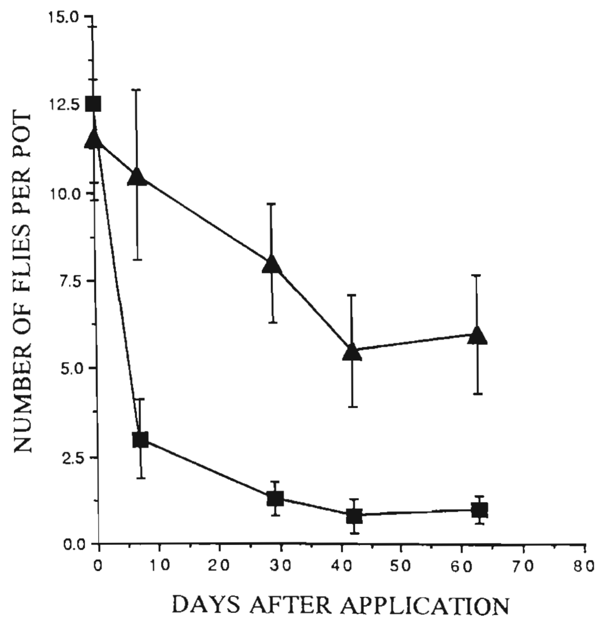

Fig. 2. *The mean number of adult* Bradysia paupera *per pot caught on sticky traps hung inside cages, treated (■) and untreated (▲). (Vertical lines are standard errors; four replicates).*

application (Table 1), with a small increase by day 64. Small numbers of infective juveniles were detected in the untreated pots, indicating that sciarid adults, infect-

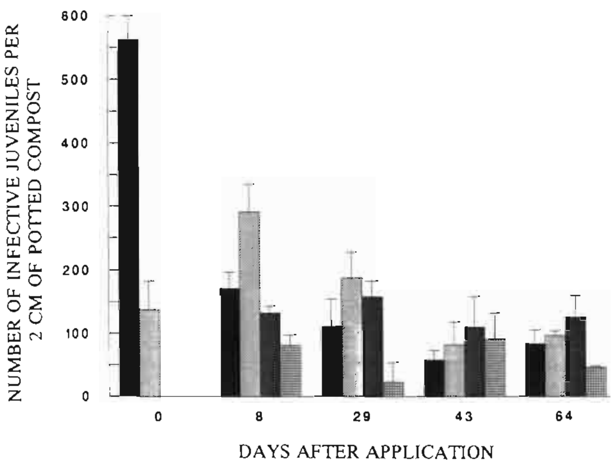

Fig. 3. *The mean number of IJs of* Steinernema feltiae *extracted by exhaustive baiting with* Galleria mellonella *from each 2 cm of pots containing fuchsias. (Vertical lines are standard errors; three replicates).*

Table 1. *The mean and standard error of the numbers of IJs of* S. feltiae *recovered by exhaustive baiting with* Galleria mellonella *for 64 days.*

Days after nematode application	Mean ♀ SE of numbers of nematodes per pot
0	701 ± 51
8	672 ± 70
29	582 ± 128
43	369 ± 137
64	536 ± 60

ed when crawling on treated pots, had moved over to untreated pots, where nematodes were transferred to the compost when the sciarid adults died.

Discussion

The maximum number of nematodes recovered from pots using the exhaustive baiting technique with *Galleria* was about 700 from a nominal application rate of 780 000 m^2. Using known numbers of nematodes applied to sand and soil, Fan and Hominick (1991) and Curran and Heng (1992) recovered between 30 and 40 % of the original inoculum. Based on their data, it is estimated that only 9 % of the original inoculum reached the pots using the hydraulic sprayer.

After 29 days nematodes were well distributed throughout the pots and IJs persisted well in the compost until the experiment was terminated. Gouge (unpubl.) has observed that *S. feltiae* enters sciarid larvae through the mouth and anus, development is extremely rapid, adult nematodes being formed within 48 h of entry : only one generation of *S. feltiae* occurs in sciarids due to the small size of the host. Sciarid flies continuously enter the glasshouse, lay eggs on the compost, so the nematodes are supplied with new hosts, hence the sciarid cadaver can yield reasonable numbers of IJs (Gouge, unpubl.). Nematode numbers in compost declined until day 43 and then increased, indicating that nematodes are being recycled as reported by Grewal and Richardson (1993).

In these experiments fly populations fell by 40-50 % in the untreated pots. With the exception of the untreated pots, the whole of the glasshouse had been treated with nematodes. Gouge (unpubl.) has shown that adult sciarids can be infected with nematodes and a low population of nematodes was detected in the untreated pots : this effect combined with the use of sticky traps probably reduced the overall population of sciarids in the glasshouse leading to an overall reduction in sciarid population.

Sticky traps are used to evaluate sciarid populations (Lindquist & Piatkowski, 1993) and also to control sciarids directly by trapping. Caging pots resulted in an estimate of 92 % control, compared to 73 % using sticky traps : caging pots eliminates contamination by flies and hence is likely to give a more accurate estimate of control.

Fungus gnats have been controlled satisfactorily in Scandinavian countries with the *S. feltiae* isolate, Biosys 27 (Georgis, pers. comm.). Most of the published data on sciarid control is on mushrooms, where *Lycoriella* species have been controlled by *S. feltiae* in the UK (Richardson & Grewal, 1991) and the USA (Nickle & Cantello, 1991). The results presented here indicate that another sciarid, *B. paupera,* can be controlled to a level satisfactory to the grower.

Sciarids are pests of protected crops either close to consumption (mushroom) or where application of pesticides might be considered undesirable (house plants). Entomopathogenic nematodes are increasingly the preferred choice for growers who favour biological control.

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