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Effects of Crop Residue on the Persistence of *Steinernema carpocapsae*[1]

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Abstract: We determined the effects of crop residue on the persistence of an entomopathogenic nematode, *Steinernema carpocapsae.* During 2 consecutive years, nematodes were applied at rates of 2.5×10^4 and 1.0×10^5 infective juveniles/m^2 to small field plots planted with corn. Nematode persistence was monitored by exposing *Galleria mellonella* larvae to soil samples from plots with and without crop residue (approximately 75% coverage of soybean stubble). Persistence of *S. carpocapsae* was significantly greater in crop residue plots than in plots without residue. In crop residue plots that received the higher rate of nematode application, larval mortality did not significantly decrease during the study period (3 to 5 days) and remained above 85%. In nematode-treated plots without crop residue, however, larval mortality fell from over 96% to below 11% and 35% in the first and second trials, respectively. The increased crop residue may have benefited nematode persistence through protection from desiccation or ultraviolet light. We conclude that increased ground cover in cropping systems (e.g., due to reduced tillage) may lead to increased insect pest suppression with entomopathogenic nematodes.

Key words: crop residue, entomopathogenic nematodes, mulch, nematode, *Steinernema carpocapsae,* survival, tillage.

A lack of predictability has slowed the widespread use of entomopathogenic nematodes (*Heterorhabditis* spp. and *Steinernema* spp.) as biological control agents for a variety of insect pests (Georgis and Gaugler, 1991). Therefore, factors that influence the efficacy (ability to suppress insect populations) of nematode applications must be determined. For example, nematode efficacy may be affected by soil characteristics such as moisture and texture (Kaya, 1990).

Mulching and tillage practices also may influence the efficacy of entomopathogenic nematodes in soil (Brust, 1991; Sweeney et al., 1998). Reduced tillage increases crop residue, which can change soil quality by increasing organic matter and moisture retention, and by decreasing erosion (National Research Council, 1989). Brust (1991) reported that reduced tillage increased the prevalence of endemic populations of *Heterorhabditis bacteriophora* Poinar relative to conventional tillage. Our objective was to determine the effects of crop residue on the persistence of *Steinernema carpocapsae* (Weiser) applied in a corn ecosystem.

Materials and Methods

The effects of crop residue on the persistence of *S. carpocapsae* Mexican strain were evaluated in two trials (1988 and 1989) at the Iowa State University Johnson Research Farm located 3.2 km south of Ames, Iowa. Experiments were conducted in a corn ecosystem within a corn-soybean rotation. The soil (Clarion-Webster) had been tilled with a disk and field cultivator. Each of 18 field plots (ca. 7.5 m × 0.6 m) contained 25 hand-planted corn seedlings cv. Garst 8538. Half of the plots were established with crop residue and half without crop residue. The ground-cover plots simulated reduced tillage by having 75% of the soil covered by hand with soybean stubble. Experiments were organized as randomized block designs with three replications and a factorial ar-

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rangement of six treatments. The treatments consisted of crop residue vs. no crop residue combined with three levels of nematode densities: 0 (control), 2.5×10^4, and 1.0×10^5 nematodes/m^2.

When corn reached the two-leaf stage (Ritchie et al., 1997), *S. carpocapsae* was applied using 10-liter plastic watering cans. Nematode suspensions were calibrated at approximately 4,000 and 1,000 infective juveniles/ml, and 50 ml of each nematode suspension was applied to each 30 cm of row length. All nematode releases were made between 19:00 and 21:00 hours.

Nematode persistence in soil was evaluated with a bioassay using the last-instar of the greater waxmoth, *Galleria mellonella* (L.) (Fan and Hominick, 1991; Shapiro et al., 1996). Twenty last-instar *G. mellonella* were exposed to 250 g of soil from each plot adjusted to approximately 20% below saturation. After 48 hours of incubation at 24 °C, *G. mellonella* larvae were removed from soil and placed on moist blotter paper for an additional 48 hours, at which time larval mortality was recorded. Persistence was evaluated 1 and 3 days after nematode inoculation in trial one, and 1, 2, and 5 days after nematode inoculation in trial two. Treatment effects were detected with analysis of variance and Duncan's multiple-range test (SAS Institute, Cary, NC).

Results and Discussion

Nematode persistence was significantly greater in crop residue plots than in plots without residue. In trial one, larval mortality dropped significantly during the 3-day test period in plots without residue, and by day 3 the nematodes failed to cause significant larval mortality relative to the control (Table 1). In crop residue plots, however, larval mortality from nematodes remained higher than in the control; in the higher rate of nematode application, larval mortality did not change significantly during the test period (Table 1).

The trends observed in trial two were congruent with those observed in trial one. In trial two, during the 5-day test period, larval mortality dropped substantially in the nematode-treated plots without crop residue relative to plots with crop residue (Table 1). In crop residue plots with the higher rate of nematodes, no significant drop in larval morality was detected during the test period. Mortality of *G. mellonella* was significantly greater in soil from crop residue plots than in plots without crop residue 2 days after nematodes were applied (Table 1).

Our findings support the hypothesis that persistence and efficacy of applied entomopathogenic nematodes will be increased in soil with crop residue. Contrarily, Sweeny et al. (1998) reported that various mulches (e.g., bark, peat, and hay) had negligible or minor effects on persistence of *Steinernema* spp. and infection of the cone maggot, *Strobilomyia neanthracina* Michelsen. Our results, however, are consistent with the findings of Brust (1991), which indicated greater survival of endemic populations of *H. bacteriophora* in reduced tillage. Because entomopathogenic nematodes are sensitive

Table 1. Mean percent *Galleria mellonella* killed by three densities of *Steinernema carpocapsae* in crop residue and conventional till plots.

		Crop residue			No crop residue		
Trial	DAT[a]	$1.0 \times 10^5/m^2$	$2.5 \times 10^4/m^2$	Control	$1.0 \times 10^5/m^2$	$2.5 \times 10^4/m^2$	Control
1	1	100a	98.3a	11.7c	98.3a	75.0b	5.0c
	3	98.3a	56.7b	6.7c	8.3c	10.0c	5.0c
2	1	98.8a	72.5bc	11.3fg	96.3a	72.5bc	11.3fg
	2	97.5a	86.3ab	5.0g	86.3b	58.8cd	3.8g
	5	85.0ab	42.5de	3.8g	33.8e	23.8ef	3.8g

[a] Last-instar *G. mellonella* were exposed to soil samples from plots with and without crop residue 1, 2, 3, or 5 days after nematode treatment (DAT). Means followed by different letters within each trial indicate significant differences according to Duncan's multiple-range test.

to desiccation and ultraviolet light (Kaya, 1990), reduced tillage and increased crop residue may provide benefits to entomopathogenic nematodes through increased ground cover. Three species of entomopathogenic fungi also were found to persist better in no-till systems relative to conventional tillage (Sosa-Gomez and Moscardi, 1994). Plant-parasitic nematodes, however, vary in their response to reduced tillage, and free-living nematodes generally are unaffected (Stinner and Crossley, 1982).

The employment of entomopathogenic nematodes for insect control generally has been restricted to curative (inundative) applications. Increased persistence of *S. carpocapsae* in cropping systems containing crop residue, e.g. reduced tillage, may allow for suitable conditions for preventative (inoculative) treatments. Agricultural fields in no-till have been suggested to support alternate insect hosts and provide soil conditions that can support nematode recycling (Kaya and Gaugler, 1993). Further studies are needed to evaluate effects of crop residue and tillage on long-term efficacy and survival of entomopathogenic nematodes in agroecosystems.

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