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WATER-ABSORBENT STARCH POLYMER: SURVIVAL AID TO NEMATODES FOR CONTROL OF *DIAPREPES ABBREVIATUS* (COLEOPTERA: CURCULIONIDAE) IN CITRUS

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ABSTRACT

A water absorbent starch polymer apparently increased survival of the entomogenous nematode *Steinernema carpocapsae* (Weiser) applied for control of a root weevil, *Diaprepes abbreviatus* (L.) on roots of *Citrus* sp. Increased mortality of wax moth, *Galleria mellonella* (L.), larvae exposed to soil from the starch polymer/nematode treated area occurred compared with water/nematode treatment alone. Mortality of *D. abbreviatus* larvae buried in the soil on the side of the tree receiving the starch/nematode treatment was 52% compared with 42% for the water/nematode and 0% for the control treatments. Enhanced infection of *G. mellonella* larvae by entomogenous nematodes was apparent for more than 2 months under field conditions.

RESUMEN

Un polímero de fécula absorbente de agua, aparentemente aumentó la sobrevivencia del nemátodo entomógeno *Steinernema carpocapsae* (Weiser) que es usado para el control de la vaquita *Diaprepes abbreviatus* (L.), en *Citrus* sp. Un aumento en la mortalidad de las larvas de la polilla de cera *Galleria mellonella* (L.), expuestas a tierra del área tratada con polímero de fécula/nemátodo ocurrió comparado con el tratamiento de agua/nemátodo solo. La mortalidad de *D. abbreviatus* enterrado en la tierra al lado del árbol recibiendo el tratamiento de fécula/nemátodo fue 52% comparado con 42% para el tratamiento de agua/nemátodo y 0% para los tratamientos de control. La acrecentada infección de las larvas de *G. mellonella* fue evidente por más de dos meses bajo condiciones de campo.

*Diaprepes abbreviatus* (L.) or the "vaquita" is a common weevil pest of sugarcane citrus and other agricultural crops in the West Indies (Ballou 1912). The weevil, first reported in the United States in 1964 in Florida, has since become a serious problem in citrus (Woodruff 1964, Schroeder & Beavers 1977). Under natural conditions, the adult oviposits between leaves of various plants. First instars drop to the ground, burrow into soil, feed on roots, pupate, and emerge as adults (approximately one year) (Wolcott 1936). Larval feeding on the roots of citrus trees leads to tree decline and mortality (Schroeder & Sutton 1977). Currently, control is limited to the application of insecticides to reduce adult populations. The short residual action, expense, environmental contamination, and human hazard involved with chemical control greatly restrict this approach in the management of *D. abbreviatus*.

Entomogenous nematodes are promising biological control agents for a broad range of soil inhabiting insect species (Poinar 1971). Beavers et al. (1983) conducted a survey of Florida citrus grove and ornamental nursery soils and found native strains of *Steinernema carpocapsae* (Weiser) and *Heterorhabditis heliothidis* (Khan et al.) that were infectious to *D. abbreviatus* larvae. Entomogenous nematodes were subsequently evaluated in greenhouse and field tests and found to have potential as biological control agents for larvae of *D. abbreviatus* (Beavers 1984, Schroeder 1987).

Soil moisture is a limiting factor in the survival of entomogenous nematodes under field conditions (Poinar 1971). Evaporative retardants, water thickeners, and gels have been evaluated to enhance nematode efficacy (Webster & Bronskill 1968, Kaya & Reardon 1982, MacVean et al. 1982, Kaya & Nelson 1985). A water-absorbent polymer was used as an aid in the infestation of field sites with the root-knot nematode, *Meloidogyne* spp. (Fortnum et al. 1987). Hence, field tests were conducted to determine if a water retention agent could be used as an adjunct when the entomogenous nematode *S. carpocapsae* was applied for control of *D. abbreviatus* larvae.

#### MATERIALS AND METHODS

The nematode *S. carpocapsae* (All strain) was obtained from Biosys (Palo Alto, California), and maintained on water-soaked sponges at 10°C. Nematodes were checked for mobility by microscopic examination before application. Wax moth, *Galleria mellonella* (L.), larvae were obtained from Northern Bait (Chetek, Wisconsin) and *D. abbreviatus* larvae (3 months old, 602 ± 7 mg SEM) were reared on an artificial medium (Beavers 1983).

The citrus grove was located near Lake Gem, FL, and planted on a Lakeland sandy soil (thermic, coated typic quartzipsamments, 95% sand, less than 5% clay silt). There are 173 trees per ha. (7.6 m between trees and rows). The 10-year-old grove was managed by a private grove service, and the average tree height was 3.0 m.

One hundred soil samples were taken in April 1987 from the Lake Gem grove to determine levels of indigenous populations of steinernematid or heterorhabditid nematodes. A sample consisted of a 100 x 15 mm petri dish of soil at 12% field moisture. Five wax moth larvae were added to each dish and examined for entomogenous nematodes after 7 days (Bedding & Akhurst 1975). For comparison, 100 soil samples were taken from a grove that had an apparent endemic population of entomogenous nematodes (Beavers et al. 1983).

The tank mix contained 2.5 million nematodes per liter. The water-absorbent starch polymer (Ag Sorbent Flakes, Super Absorbent Co., Lumberton, North Carolina) was added to half the tank mix at 5 g per liter. One liter of the tank mix with and without the starch polymer was placed in a 10 cm deep by 20-cm circular depression on the east (E) and west (W) of 10 trees each month for 3 months (September, October, and November) for a total of 30 trees.

To determine the effect of the starch polymer when nematodes were applied directly to the soil surface, an application was made on the E-W side of 10 trees with and without the starch polymer in November. The soil surface covered by one liter with the polymer was 30 cm in diam. and the area without the polymer was 40 cm in diam. and irregular.

Five soil samples of 100 g each, 0 to 10 cm deep were taken from treated sides of each tree 2, 4, and 8 weeks after treatment and 5 wax moth larvae were placed in each sample and maintained at 27°C for 1 week. Dead larvae were dissected to determine the presence or absence of nematodes.

*D. abbreviatus* larvae were buried individually in 10 x 10 x 4 cm screen cages. Each cage held 150 ml of soil and was buried 10 cm below the surface on the E-W side of trees in treated zones. There were 8 trees, 20 cages per tree. Four trees (80 weevils) were treated with the starch polymer and 4 (80 weevils) with no polymer in the tank mix. Nematodes were applied to the soil surface at the rate of 25 nematodes per cm<sup>2</sup> in one liter of water per tree. Forty larvae in cages were buried adjacent to 2 untreated trees as checks. The cages were recovered 21 days later and larvae dissected to determine nematode infection.

## RESULTS AND DISCUSSION

None of the 500 wax moth larvae added to the 100 soil samples taken from the Lake Gem grove became infected with entomogenous nematodes. Conversely, we recovered 160 nematode-infected larvae from the grove with a known endemic population. Because of the apparent lack of this biocontrol agent in the test grove, larval mortality caused by nematodes was attributed to introductions and not to an endemic population.

Addition of the starch polymer to the tank mix increased mortality of wax moth larvae (Table 1). The introduced nematodes persisted for more than 2 months. Surface application of the nematodes with starch in the tank mix was significantly better than water only. This method of application could be used during periods of high rainfall or with grove irrigation.

Fifty-two  $\pm$  5% (SEM) of larvae recovered from cages placed in the polymer treated soil were dead, compared to 42  $\pm$  3% of larvae treated with water only (significantly different by *t* test, *t* = 2.83; *df* = 6; *P* < 0.05). None of the 40 larvae placed in untreated soil died in the 3-week period. The total effect of nematodes would probably have been greater if larvae had been exposed for more than a month. Identification of nematode infected larvae, pupation, and lack of food limited the exposure period. Additional field trials with adult ground emergence traps are required to assess the use of nematodes as a biological control agent for larvae of *D. abbreviatus* feeding on citrus under Florida conditions.

This study has demonstrated that use of a water retention agent in the tank mix increased mortality of insect larvae by entomogenous nematodes. This was probably due to nematode survival in the moist soil.

## ENDNOTE

This paper reports the results of research only. Mention of a proprietary product does not constitute an endorsement of a recommendation for its use by USDA.

TABLE 1. PERCENTAGE MORTALITY OF *GALLERIA MELLONELLA* LARVAE DUE TO *STEINERNEMA CARPOCAPSAE* IN SOIL TREATED WITH A STARCH POLYMER AND NEMATODES COMPARED WITH NEMATODES IN WATER ONLY.

Date	Application method	% mortality in a soil sample weeks post treatment			% Total mortality
		2	4	8	
Sept.	Starch	91**	72	44	69
	Water	76	64	44	61
Oct.	Starch	100	93	38*	77
	Water	100	88	28	72
Nov.	Starch	100	48**	59**	69**
	Water	100	39	12	50
Nov.	Starch	92*	56	38*	62**
	(surface app.) Water	70	45	20	45

\*significant at the 0.05 level; \*\*significant at the 0.01 level (paired *t* test).

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