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MANAGEMENT OF DIAPREPES ROOT WEEVIL, *DIAPREPES ABBREVIATUS* (COLEOPTERA: CURCULIONIDAE), IN ORNAMENTALS

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Abstract. ***Diaprepes abbreviatus*** **(Coleoptera: Curculionidae), an introduced pest, has spread over a large area of central and southern Florida where it is damaging citrus, ornamental plants, sugarcane and numerous other crops. In addition to the damage caused by this pest, there are regulatory concerns of spreading *Diaprepes* to non-infested areas. This is particularly important in the ornamental industry because plants are shipped throughout the U.S. and abroad. Previous research has demonstrated that bifenthrin (Talstar) is efficacious against neonates and young larvae, and that some entomopathogenic nematodes are efficacious against various stages of larvae. Bifenthrin is currently recommended as a drench, or incorporated into the potting media, at a rate of 25 ppm based on the bulk density of the media. Tests were conducted to evaluate bifenthrin and entomopathogenic nematodes, alone and in combination, for control of older larvae (ninth instar) in ornamentals. In all cases, the combination treatment of bifenthrin and the entomopathogenic nematodes provided the best control, suggesting a synergy or additive effect between treatments. In a natural environment, the nematodes may be more efficacious against different aged larvae than the bifenthrin and therefore, improve control. The addition of nematodes may also provide a way to reduce the rate of insecticide currently recommended.**

Diaprepes abbreviatus (L.) (Coleoptera: Curculionidae), an introduced pest, has spread over a large area of central and south Florida where it is damaging citrus, ornamental plants, sugar cane and numerous other crops (Knapp et al., 2001; Simpson et al., 1996). In addition to the damage caused by this pest, there are regulatory concerns of spreading *D. abbreviatus* (Diaprepes root weevil) to non-infested areas. These concerns are particularly important for the ornamental industry, which ships plants throughout the U.S. and abroad. Currently in the U.S., Diaprepes root weevil infests 22 counties in Florida and one county in Texas. Previous research from the citrus environment has demonstrated that bifenthrin is efficacious against neonates (newly hatched) and young larvae, and that some entomopathogenic nematodes [*Heterorhabditis indica* (Poinar, Kanunakar, and David), *H. bacteriophora* (Poinar), and *Steinernema riobrave* (Cabanillas, Poinar, and Raulston)] are efficacious against young larvae (McCoy et al., 1995; McCoy et al., 2001; Shapiro and McCoy, 2000; Shapiro et al., 1999). Bifenthrin is currently recommended as a drench, or incorporated into the potting media, at a rate of 25 ppm based on the bulk density of the media. The 25 ppm rate is equivalent to the high drench rate for imported fire ants. Both *H. indica* and *S. riobrave* are commercial products and are currently recommended for use against early instar Diaprepes root weevil in citrus. However, no data exists on how efficacious bifenthrin or the nematodes are in container-grown ornamentals. Additionally, no products have been shown to be highly efficacious against late instar Diaprepes root weevil.

It has been suggested that combining insecticides, or reduced rates of insecticides, with biological control could achieve adequate control while reducing the adverse effects of insecticides. Numerous studies have demonstrated additive or synergistic relationships between the combined use of low-impact insecticides and biological control agents (Boucias et al., 1996; Kaakeh et al., 1997; Koppenhofer and Kaya, 1998; Koppenhofer et al., 2000; Nishimatsu and Jackson, 1998; Quintela and McCoy, 1997, 1998). Koppenhofer and Kaya (1998) described a strong synergistic effect on mortality of two scarab species, *Cyclocephala hirta* LeConte and *C. pasadenae* Casey with combinations of imidacloprid and entomopathogenic nematodes. The synergistic interaction occurred at recommended and reduced field rates of imidacloprid. Mannion et al. (2000) demonstrated that there was no synergy between entomopathogenic nematodes and halofenozide when used in combination against third instar Japanese beetle, however, there were no deleterious effects.

Laboratory tests were conducted to evaluate the efficacy of entomopathogenic nematodes and bifenthrin used in combination for control of late instar Diaprepes root weevil.

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Table 1. Effect of Bifenthrin (Talstar) and nematode, *Heterorhabditis indica*, on 9th instar Diaprepes root weevil in a laboratory bioassay.

Treatment	Mean No. Live Larvae (Days After Treatment)				
	2	3	4	5	6
H. indica – low[z]	2.6 ab[v]	2.1 a	1.7 ab	1.5 b	1.2 bc
H. indica – high[y]	2.5 ab	2.2 a	1.7 ab	1.3 bc	1.3 ab
Talstar – low[x]	1.9 abc	1.4 ab	1.2 bc	1.0 bcd	0.9 bcd
Talstar – high[w]	2.0 abc	1.7 ab	1.4 ab	1.1 bc	0.9 bcd
H. indica-low + Talstar-low	1.5 bc	0.7 b	0.6 bcd	0.3 cd	0.2 cd
H. indica-low + Talstar-high	1.8 abc	1.7 ab	1.3 b	0.6 bcd	0.6 bcd
H. indica-high + Talstar-low	1.6 abc	0.7 b	0.0 d	0.0 d	0.0 d
H. indica-high + Talstar-high	1.1 c	0.7 b	0.1 cd	0.0 d	0.0 d
Control	2.7 a	2.6 a	2.5 a	2.5 a	2.2 a

[z]Low rate of nematodes—1 billion per acre.
[y]High rate of nematodes—2 billion per acre.
[x]Low rate of bifenthrin (Talstar)—12.5 ppm based on bulk density weight.
[w]High rate of nematodes—25 ppm based on bulk density weight.
[V]Mean separation in columns by Tukey's Studentized Range Test, 5% level.

Materials and Methods

Two tests were conducted. *Heterorhabditis indica* was evaluated in one test and *S. riobrave* was evaluated in a second test. All other test parameters were the same. Ninth instar Diaprepes root weevils were exposed to two rates of bifenthrin (Talstar) (12.5 and 25 ppm = 4.4 and 8.9 fl oz per 100 gal based on the media bulk density of 739 lbs/yd^3), two rates of nematodes (1 and 2 billion per acre or approximately 1,400 and 2,800 per container, respectively), and all combinations of bifenthrin and the nematodes. Three ninth instars were buried in 8-oz containers filled with potting media. A small carrot was provided for food for the larvae. Each container was treated with the nematodes, Talstar or combination of products 4 d after the larvae were introduced. Nematodes were applied in less than 2 mL and the Talstar was applied in 50 mL per container. Combination treatments with the nematodes and Talstar were applied in succession and not in a mixed solution. Control treatments received an equivalent amount of water. The number of live larvae in each container was evaluated daily for 6 d starting 2 d after treatment application. Containers were held in an incubator (26 °C) for the duration of the test. Experimental design was random with 10 replications per treatment for both tests. The data were transformed [log (x+1)] and subjected to ANOVA. Significant means were separated with Tukey's Studentized Range Test.

Results and Discussion

Nursery growers must treat plant material infested with the Diaprepes root weevil prior to shipping. Although there are data for management of this pest in citrus, there are little to no data for soil treatments for immature stages of this pest in ornamentals. Additionally, there are no proven options for control of late instar Diaprepes root weevil. The results of these tests demonstrate the potential of combining a biological agent and a pesticide for control of late instar Diaprepes root weevil.

There were no significant differences between the two rates of either nematode (1 and 2 billion per acre) or between the two rates of Talstar (12.5 and 25 ppm) in the number of live larvae recovered at all evaluation times in both tests (Tables 1 and 2). The combination treatments of the high rate of *H. indica* and either rate of Talstar performed the best and were significantly better than the control at all evaluation times and significantly better than either rate of nematodes

Table 2. Effect of Bifenthrin (Talstar) and nematode, *Steinernema riobrave*, on 9th instar Diaprepes root weevil in a laboratory bioassay.

Treatment	Mean No. Live Larvae (Days After Treatment)				
	2	3	4	5	6
S. riobrave – low[z]	2.7 a[V]	2.1 ab	1.8 ab	1.3 b	1.1 b
S. riobrave – high[y]	1.9 abc	1.6 ab	1.4 b	1.4 b	0.9 b
Talstar – low[x]	2.1 ab	1.4 bc	1.3 b	1.1 b	1.0 b
Talstar – high[w]	2.2 ab	1.3 bc	0.9 bc	0.6 bc	0.4 bc
S. riobrave -low + Talstar-low	0.9 cd	0.5 cd	0.3 c	0.2 c	0.1 c
S. riobrave -low + Talstar-high	1.2 bcd	0.2 d	0.0 c	0.0 c	0.0 c
S. riobrave -high + Talstar-low	0.7 d	0.1 d	0.1 c	0.1 c	0.0 c
S. riobrave -high + Talstar-high	0.3 d	0.1 d	0.0 c	0.0 c	0.0 c
Control	2.7 a	2.6 a	2.4 a	2.3 a	2.0 a

[z]Low rate of nematodes—1 billion per acre.
[y]High rate of nematodes—2 billion per acre.
[x]Low rate of bifenthrin (Talstar)—12.5 ppm based on bulk density weight.
[w]High rate of nematodes—25 ppm based on bulk density weight.
[V]Mean separation in columns by Tukey's Studentized Range Test, 5% level.

used alone at 3, 4, 5, and 6 d after treatment (Table 1). However, these two treatments were not significantly different from Talstar in three of the five evaluations, but they were the only two treatments resulting in 100% control. Similar results were observed for *S. riobrave*. All the combination treatments performed significantly better than the control and either rate of nematodes alone at 3, 4, 5, and 6 d after treatment (Table 2). The high rate of *S. riobrave* in combination with either rate of Talstar, and the low rate of the nematodes in combination with the high rate of Talstar, ultimately provided 100% control. Overall, the combination of entomopathogenic nematodes and Talstar provided increased control of late instar Diaprepes root weevil.

Although more testing is necessary, the results of these laboratory tests provide useful information on management of Diaprepes root weevil in ornamental production. It was demonstrated that a combination of a natural enemy and a pesticide could increase control of this pest. These results also provide an option for controlling larger, older larvae that have been traditionally difficult to control. Lastly, combining these treatment methods may provide an avenue to reduce the use of the pesticide by using a lower rate.

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