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Activity of eight strains of entomopathogenic nematodes (Rhabditida: Steinernematidae, Heterorhabditidae) against five stored product pests

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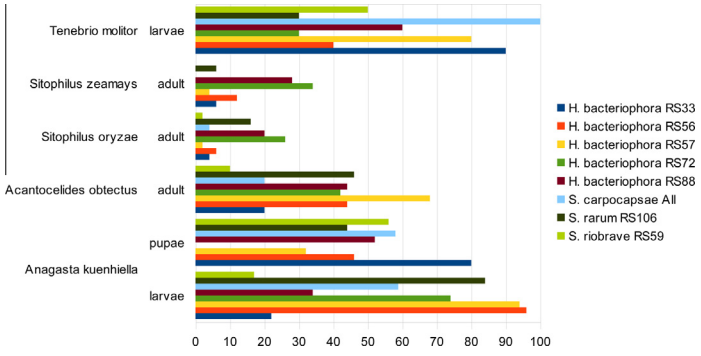
HIGHLIGHTS

- Stored product pests (SPP) are susceptible to entomopathogenic nematodes (EPNs).
- The virulence of species/strains of EPNs varies with the species of SPP.
- EPNs are candidates for biocontrol of SPP, once applied for purging the warehouses.

GRAPHICAL ABSTRACT



Percentage mortality (±SE) of larvae of five species of stored product pests five days after exposure to different species/strains of entomopathogenic nematodes (10 IJs/insect) in the laboratory.

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Biocontrol

ABSTRACT

Stored product pests are responsible for losses that can amount 10% during cereal storage in the world. Aiming to find an alternative method to the chemicals used for the stored-product pests, eight strains of entomopathogenic nematodes (EPNs) were tested against five species of stored product pests. The bioassays were conducted in microtubes containing paper, inoculated with EPNs and insect diet. All the insect species were susceptible to the EPNs strains. *Anagasta kuehniella* and *Tenebrio molitor* larvae and *Acanthoscelides obtectus* adults were highly sensitive to the higher doses with most species and/or strains of EPNs. Adults of *Sitophilus oryzae* and *Sitophilus zeamais* were relatively less sensitive to all EPNs. Therefore, EPNs show as potential control agents for stored products pests in prophylactic applications in warehouses.

1. Introduction

Losses of agricultural products from the planting until the harvesting amount approximately 30%, caused by the action of insect pests, diseases, weeds and climate. After harvesting, losses in-

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crease, nearing 40% due to the action of insects and rodents (Loeck, 2002). The most important stored-product pests belong to the Lepidoptera and Coleoptera orders. These insects cause damages by feeding on grains causing weight and germination loss, by increasing the temperature and humidity in the grain mass, by causing product contamination by residues (excrements and body fragments) and obstruction of agricultural equipment. Moreover, insects can increase the incidence of diseases to humans due to the micotoxins produced (Ramos-Rodriguez et al., 2006).

The control of stored-product pests is usually done by applying chemical insecticides, however over the last years, it has been noticed that populations of the main species, such as *Rhyzopertha dominica* (Fabr.) (Coleoptera: Bostrichidae), *Sitophilus zeamais* Motschulsky 1885, *Sitophilus oryzae* L. (Coleoptera: Curculionidae), *Tribolium castaneum* (H.) (Coleoptera: Tenebrionidae) and *Oryzaephilus surinamensis* L. (Coleoptera: Silvanidae) have shown resistance to agrochemicals. (Beckel et al., 2006; Fragoso et al., 2003, 2007; Gonçalves et al., 2007; Guedes and Dover, 1997; Guedes et al., 1997; Pimentel et al., 2007). Thus, studies on alternative methods to the chemical control as well as the biological control of this insects group are necessary, in compliance with procedures of IPM (Integrated Pest Management).

The reasons for EPNs to be potential candidates for the control of stored-product pests involve their capacity of active search for hosts in cryptic habitats and the possibility of application with the same equipment used for chemical insecticide (Ramos-Rodriguez et al., 2006). EPNs cannot be applied directly to the grains mass due the low humidity. Therefore, EPNs should be applied in the prophylaxis of storage rooms, in crevices and holes, shelter sites of pests. Few studies (Athanassiou et al., 2008, 2010; Laznik et al., 2010; Trdan et al., 2005, 2006; Ramos-Rodriguez et al., 2006, 2007) report on the EPNs effect on these insects, limiting only the some steinernematids in laboratory, making this the first study conducted on this issue in Brazil. Therefore, the objective of this study was to investigate the efficacy of heterorhabditids and steinernematids on five species of stored-product pests in laboratory.

2. Material and methods

Five of the main species of stored-product pests in Brazil were evaluated in this study: *S. zeamais*, *S. oryzae*, *A. obtectus* adults, *T. molitor* larvae, *A. kuehniella* larvae in prepupal and pupal stages. All insects were reared on a natural diet and assayed in the Laboratory of Insects Biology and Biological Control, Federal University of Pelotas, Rio Grande of the Sul, Brazil.

Eight strains of EPNs were tested, seven native to the Rio Grande of the Sul state: *H. bacteriophora* Poinar, 1976 (RS33, RS56, RS57, RS72, RS88), (Barbosa-Negrisoli et al., 2009). *Steinernema riobrave* Cabanillas, Poinar and Raulston, 1994 (RS59), *S. rarum* (Doucet, 1986) (RS106) and one strain from Georgia, USA. The EPNs were multiplied in the last instar *G. mellonella* larvae (Kaya and Stock, 1997) and stored in polyurethane sponges in zip-lock bags, kept at 12 °C until a month before of the laboratorial bioassays.

The insects were individuated in microtubes (1.5 mL) (Ramos-Rodriguez et al., 2006) containing a filter paper piece (0.52 cm^2) and diet for each species: maize grains to *Sitophilus* spp., beans to *A. obtectus* (one grain for each tube), wheat flour (about 0.01 g) to *A. kuehniella* and soybean bran and maize flour to *T. molitor*. The insects were exposed to 50 μL of aqueous suspension of each nematode at the following doses: 0 (water only), 10, 20, 50, 100 and 200 JIs/micro tubes conducted at 25 °C, RH of 70 ± 10% and photophase 12 h. The experiment design was a factorial (5 × 8),

Table 1
Percentage mortality (±SE) of larvae of five species of stored product pests five days after exposure to different species/strains of entomopathogenic nematodes (10 IJs/tube) in the laboratory.

EPN/Insects	*Anagasta kuehniella*		*Acanthoscelides obtectus*	*Sitophilus oryzae*	*Sitophilus zeamais*	*Tenebrio molitor*
	Larvae	Pupae	Adult	Adult	Adult	Larvae
H. bacteriophora RS33	22.0 ± 0.8 d	80.0 ± 0.99 a	20.0 ± 1.6 c	4.0 ± 1.2 b	6.0 ± 0.34 c	90 ± 1.34 a
H. bacteriophora RS56	96.0 ± 1.3 a	46.0 ± 1.3 bc	44.0 ± 1.3 b	6.0 ± 0.34 ab	12.0 ± 0.45 bc	40.0 ± 0.43 cd
H. bacteriophora RS57	94.0 ± 1.1 ab	32.0 ± 1.4 c	68.0 ± 1.2 a	2.0 ± 0.34 b	4.0 ± 0.23 c	80.0 ± 1.4 ab
H. bacteriophora RS72	74.0 ± 0.91 bc	56.0 ± 0.98 b	42.0 ± 0.99 b	26.0 ± 0.98 a	34.0 ± 0.43 a	30.0 ± 0.45 d
H. bacteriophora RS88	34.0 ± 0.20 d	52.0 ± 1.56 bc	44.0 ± 0.96 b	20.0 ± 1.2 ab	28.0 ± 1.4 ab	60.0 ± 1.3 bc
S. carpocapsae	58.8 ± 0.35 c	58.0 ± 0.75 b	20.0 ± 0.86 c	4.0 ± 0.23 b	0.0 ± 0.0 c	100 ± 0.0 a
S. rarum RS106	84.0 ± 1.2 ab	44.0 ± 0.95 bc	46.0 ± 1.57 b	16.0 ± 0.34 ab	6.0 ± 0.23 c	30.0 ± 1.2 d
S. riobrave RS59	17.0 ± 0.99 d	56.0 ± 0.87 b	10.0 ± 1.26 c	2.0 ± 0.12 b	0.0 ± 0.0 c	50.0 ± 1.5 cd

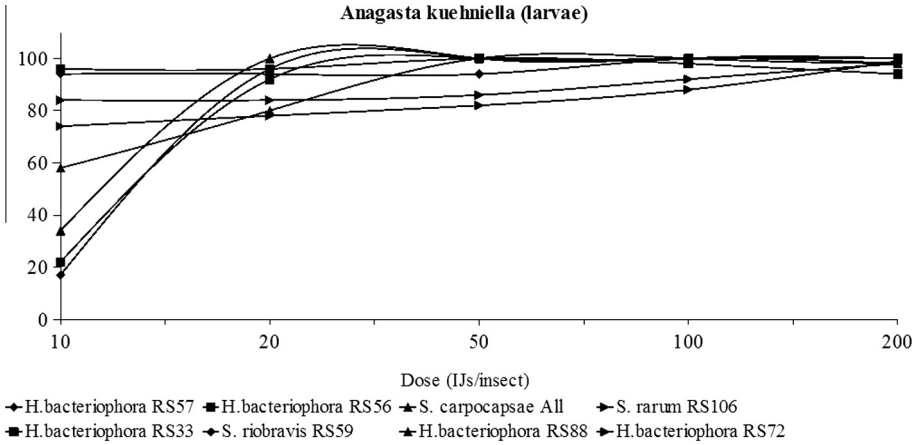

Fig. 1. Mortality of larvae of *Anagasta kuehniella* five days after exposure to different species/strains of entomopathogenic nematodes in laboratory.