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Compatibility of biological agents to control Spodoptera frugiperda (Lepidoptera: Noctuidae)

Compatibilidade de agentes biológicos para controlar *Spodoptera frugiperda (Lepidoptera: Noctuidae)*

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Abstract. *Spodoptera frugiperda* (Lepidoptera: Noctuidae) is the main insect pest of corn in the Americas. The objective was to evaluate the performance of *Trichogramma atopovirilia* (Hymenoptera: Trichogrammatidae) with influence of *Bacillus thuringiensis* var. *kurstaki* (*Bt*) (Bacillaceae) (Dipel™ PM) to control of *S. frugiperda*. *S. frugiperda* eggs were immersed in solution of *Bt* and submitted to parasitism for 24 hours. The experiment was kept in acclimatized chamber at temperature of 25 ± 1ºC, relative humidity of 70 ± 10% and photophase of 14 hours. The parasitism, emergence, number of individuals per egg, sex ratio of offspring and longevity of females that parasitized were used as indicators of compatibility between the biological control agents. There was no difference in any biological characteristics of *T. atopovirilia* induced by *Bt*. The commercially *B. thuringiensis* formulated as Dipel™ PM applied on *S. frugiperda* eggs not affect *T. atpovirilia*.

Keywords. Entomopathogen, integrated pest management, parasitoid.

Resumo. *Spodoptera frugiperda* (Lepidoptera: Noctuidae) é o principal inseto-praga do milho no continente americano. O objetivo do trabalho foi avaliar o desempenho de *Trichogramma atopovirilia* (Hymenoptera: Trichogrammatidae) sob influência de *Bacillus thuringiensis* var. *kurstaki* (*Bt*) (Bacillaceae) (Dipel PM®) no controle de *S. frugiperda*. Ovos de *S. frugiperda* foram mergulhados em suspensões de *Bt* e submetidos ao parasitismo por 24 horas. O experimento foi mantido em câmara climatizada com temperatura de 25 ± 1ºC, umidade relativa de 70 ± 10% e fotofase de 14 horas. O parasitismo, emergência, número de indivíduos por ovo, razão sexual dos descendentes e longevidade das fêmeas que parasitaram foram avaliados como indicadores de compatibilidade entre os agentes de controle biológico. Não houve diferença em nenhuma das características biológicas de *T. atopovirilia* induzidas por *B. thuringiensis* formulado comercialmente como Dipel PM® aplicado em ovos de *S. frugiperda*.

Palavras-chave. Entomopatógeno, manejo integrado de pragas, parasitóide.

Introduction

The fall armyworm *Spodoptera frugiperda* (Lepidoptera: Noctuidae) is one of the most destructive insect pest in agriculture (Tavares et al. 2009). Its attack has economic importance for different crops (Murúa et al. 2006; Tavares et al. 2009; Tavares et. al. 2010).

The control of this insect is usually accomplished with insecticides of broad spectrum and high economic and environmental cost (Lima et al. 2006; Storer et al. 2010). The adverse effects of pesticides can be minimized with other tactics such as the biological control.

Spodoptera frugiperda has a broad complex of natural enemies such as the egg parasitoids of the genus *Trichogramma* and entomopathogenic fungi. *Trichogramma atopovirilia* (Hymenoptera: Trichogrammatidae) is the better species to

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control *S. frugiperda* (Bezerra & Parra 2004). On the other hand, *Bacillus thuringiensis* var. *kurstaki* (*Bt*) (Bacillaceae) is the most studied and used to control *S. frugiperda* (Roh et al. 2007). Insecticidal proteins produced by *Bacillus thuringiensis* are used to control insect pests in agriculture as spray products (Glare & O'callagham 2000) or by the use of genetically engineered crops that express *Bt* toxins (Hakim et al. 2010). On the other hand, little knowledgement about the possible action of these toxins in no target organisms (Glare & O'Callagham 2000; Ruiu et al. 2007). Thus, compatibility among tools for biological control must be asses to determine the effects of possible negative interactions to increase the efficiency of Integrated Pest Management. The risk of *Bt* on non-target organisms depends on the species, dose and the probability of exposure in the environment (Glare & O'Callagham 2000).

The objective was to evaluate the influence *B. thuringiensis* in biological characteristics of *T. atopovirilia* on *S. frugiperda* eggs.

Material and Methods

The experiment was conducted at laboratory of Entomology and Phytopatology from Universidade Federal do Espírito Santo, Alegre, Espírito Santo state, Brazil, The work was carried out in acclimatized chamber at temperature of 25 ± 1ºC, relative humidity of 70 ± 10% and photophase of 14 hours.

Twenty females of *T. atopovirilia* population up to 24 h after emergence were individualized in tubes (8.0 × 2.5 cm) with a honey droplet (as food) in its internal wall. Thirty *S. frugiperda* eggs (Andrade et al., 2010) were glued on a cardboard strip (4.0 × 2.5 cm) and immersed for 5 seconds in *Bt* solution at concentration of 10^7 sporos mL^{-1} bioinsecticide based on *Bacillus thuringiensis* var. *kurstaki* (Dipel™ PM) (Cônsoli et al. 2001, Pratissoli et al. 2010). Distilled water was used as control. The cardboard strips with eggs were then exposed to parasitism by *T. atopovirilia* for 24 hours (Vianna et al. 2009), time required for recognition and parasitism by parasitoid without host superparasitism. After this period, the cardboards were transferred to glasses tubes (8.0 × 2.5 cm) and kept in acclimatized chamber until emergence of adults.

Parasitism, emergence, sex ratio and number of individuals per egg and longevity were evaluated. Parasitism was obtained by the number of eggs parasitized per boardcard. The percentage of emergence was determined by the rate between the eggs with hole of emergence of the parasitoid and eggs parasitized. The value obtained was converted in percentage. The sex ratio was obtained by the rate between the number female and the total of individuals emerged. The number of individuals per egg was obtained by the ratio of number of total eggs parasitoids and total of eggs with holes. The longevity of females that parasitized was evaluated daily.

The experimental design was completely randomized with 20 replications and the results were subjected to analysis of variance at 5% probability.

Results and Discussion

Parasitism of *T. atopovirilia* was similar in treated and untreated *S. frugiperda* eggs with *Bt* (Table 1), indicating that the bacteria did not affect negatively the performance of these parasitoids. The oviposition behavior of *Trichogramma* spp. comprises steps in which the female makes an assessment of the egg to determine the acceptance or rejection of it (Beserra & Parra 2003).

The good acceptance of the eggs containing the entomopathogen suggests that the strategy of simultaneous use of this biological control agent can be successful. *Anagasta kuehniella* eggs (Lepidoptera: Pyralidae) with different *Bt* strains did not reduce parasitism by *Trichogramma pratissolii* (Pratissoli et al. 2006). One possible answer is kairomones that stimulate the host recognition behavior and oviposition in the hosts by parasitoid did not change when these eggs are treated with the entomopathogenic bacterium. However, egg viability was affected by isolates used by Pratissoli et al. (2006). This was not observed for *T. atopovirilia* on *S. frugiperda*. This may be related to the physicochemical characteristics of the host eggs or interspecific differences between parasitoids. Thus, emergence of offspring was over 95% (Table 1), without the influence of *Bt* on the development its progeny. The quality control of emergence for *Trichogramma* spp. is above 85% (Navarro 1998). The high emergence of *T. atopovirilia* is emphasized by several authors, both in natural and

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factitious hosts. Nicoli et al. (2004) report 96% of emergence in *A. kuehniella* eggs. The emergence of this species, also, was high *Diaphania hyalinata* (Lepidoptera: Pyralidae) eggs (Melo et al. 2007).

The number of individuals per egg also was similar between eggs treated and without *Bt* (Table 1). On the other hand, the result differ for this species in study of biology with 1.4 individuals per egg (Bezerra & Parra 2004). This difference is due to *Trichogramma* strains may have different size and behavior, what is natural in environment (Bleicher & Parra 1989).

The sex ratio in the treatment with *Bt* (0.72) did not differ from control (0.81) (Table 1). The minimum value for quality of parasitoids to control pests is 0.5 (Navarro 1998). The time of parasitism, 24 hours, which corresponds to early adult life may have influenced the parasitoid, because the sex ratio of offspring is inversely proportional to age female (Hoffmann et al. 1995). However, biotic or abiotic stress, often changing the sex ratio (Melo et al. 2007), this indicates the suitability of *S. frugiperda* eggs to progeny of *T. atopovirilia*.

Table 1. Mean (± SE) of parasitism, emergence, individuals per egg, sex ratio and longevity of *Trichogramma atopovirilia* Oatman & Platner (Hymenoptera: Trichogrammatidae) on *Spodoptera frugiperda* J.E. Smith (Lepidoptera: Noctuidae) eggs untreated and treated with *Bacillus thuringiensis* var. *kurstaki* (Dipel™ PM), (25 ± 1º C, RH = 70 ± 10% and photoperiod = 14 h).

Characteristics	Control	*B. thuringiensis*
Parasitism (%)	71.29 ± 1.23 a	69.0 ± 0.95 a
Emergence (%)	95.30 ± 0.95 a	95.33 ± 2.7 a
Individuals/egg	1.06 ± 0.16 a	1.1 ± 0.09 a
Sex ratio	0.81 ± 0.09 a	0.72 ± 0.02 a
Longevity	8.00 ± 0.67 a	7.7 ± 0.67 a

Means followed by same letter do not differ significantly on the line by ANOVA at 5% probability.

The longevity of females that parasitized also not different (Table 1), what indicate that the bacteria did not affect the survival of *T. atopovirilia*. This parasitoid showed 6.6 days when did not receive eggs and 11.4 days for those receiving daily *Anticarsia gemmatalis* (Lepidoptera: Noctuidae) eggs (Cañete & Foerster 2003). Beserra & Parra (2003) reports longevity between 2.6 and 9.9 days for females of 20 strains of *T. pretiosum* in *S. frugiperda* eggs. The absence of negative effects on longevity is very important, because the female can feed the liquid extravasated during oviposition (Beserra & Parra, 2003) and thus ingest spores in treated eggs of *Bt*.

Conclusion

Bacillus thuringiensis (Dipel™ PM) applied on *Spodoptera frugiperda* eggs not affects the biological characteristics of *Trichogramma atopovirilia* in laboratory.

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