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Insecticidal efficacy of diatomaceous earth against *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae) and *Tribolium confusum* du Val (Coleoptera: Tenebrionidae) on stored wheat: influence of dose rate, temperature and exposure interval

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Abstract

Laboratory experiments were conducted in order to assess the insecticidal effect of a diatomaceous earth formulation (Silicosec®, Biofa GmbH, Germany) against *Sitophilus oryzae* and *Tribolium confusum* on stored wheat. Adults of the two species were exposed on wheat treated with diatomaceous earth at four dose rates: 0.25, 0.5, 1 and 1.5 g/kg of wheat, respectively. For each dose rate, the treated wheat was placed at 22°C, 25°C, 27°C, 30°C and 32°C. Dead adults were counted after 24 and 48 h, 7 and 14 d of exposure. After the 14-d interval, the live adults were removed and placed for 7 d in untreated wheat (in the case of *S. oryzae*) or untreated flour (in the case of *T. confusum*), and the production of F_1 was recorded. For both species, dose rate, temperature and exposure interval significantly affected mortality ($P<0.001$). Mortality was higher at longer exposure intervals. The efficacy of SilicoSec against *S. oryzae* increased with temperature, but for *T. confusum* mortality was lower at 32°C, compared to 30°C, for 24 and 48 h exposure intervals. *Tribolium confusum* proved less susceptible to SilicoSec than *S. oryzae*. In general, the rates of 1 and 1.5 g/kg of wheat provided a satisfactory level of protection against the two species examined. For *S. oryzae*, F_1 emerged only at 22°C, in wheat treated with 0.25 or

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0.5 g/kg. However, for *T. confusum*, F_1 were recorded at 22°C for 0.5 g/kg and at 22°C, 25°C, 27°C and 30°C for 0.25 g/kg.

Keywords: Diatomaceous earth; Stored wheat; *Sitophilus oryzae*; *Tribolium confusum*; Natural insecticides; Inert dusts; SilicoSec

1. Introduction

Residual insecticides are the most commonly used protectants in stored grain against stored-product pests. These insecticides are applied directly to the product and provide protection against stored-grain pests as long as the insecticidal effect persists (Arthur, 1996). However, the use of these protectants meets with several drawbacks such as (a) they are generally toxic to mammals, (b) they leave residues in the product and (c) many species are resistant to some residual protectants (Arthur, 1996). These limitations have led researchers to evaluate the potential use of alternative control methods, such as botanicals, insect growth regulators, biological control, microbial control and inert dusts.

One of the most promising alternatives to contact insecticides is the application of diatomaceous earths (DE), which are the fossilized remains of diatoms (diatoms are unicellular algae which occurred during the Eocene and Miocene periods). Although several modes of action have been proposed (Subramanyam and Roesli, 2000), it is generally accepted that damage occurs to the protective wax layer in the insect's cuticle, resulting in water loss and desiccation (Korunic, 1998; Subramanyam and Roesli, 2000). These dusts are applied directly to the grain, without specialized equipment, using much the same technology as for residual insecticides. DE have some incontestable advantages over the residual protectants, given that (a) they are non-toxic to mammals, (b) they can be easily removed from the product during processing, (c) are very effective for a wide range of species and (d) given that only a physical method is involved, it has been postulated that physiological resistance is unlikely to occur (Golob, 1997; Korunic, 1998; Subramanyam and Roesli, 2000). However, recent studies indicate that resistance to DE can be developed under certain circumstances (Korunic and Ormesher, 2000; Rigaux et al., 2001).

In our study, we evaluated the efficacy of a relatively new formulation of DE (SilicoSec®) against two of the most destructive beetle species in stored grain, the rice weevil, *Sitophilus oryzae* (L.) and the confused flour beetle *Tribolium confusum* du Val. The rice weevil is categorized as a primary pest, which can easily infest sound seeds while the confused flour beetle is a secondary pest, which usually infests damaged or broken cereal seeds, flour and related products (Rees, 1995). The objectives of our study were (a) to evaluate the insecticidal efficacy of DE against these two species, (b) to determine the influence of exposure interval, temperature and dose rate and (c) to examine survival of exposed individuals and the capacity for progeny production after removal from the treated substrate.

2. Materials and methods

A sample of SilicoSec® was obtained from Biofa GmbH (Germany). SilicoSec is a DE formulation of freshwater origin, and contains approx. 92% SiO_2, 3% Al_2O_3, 1% Fe_2O_3, and 1%