



Control of the lesser grain borer (*Rhyzopertha dominica* (F.), Coleoptera: Bostrichidae) by treatments with residual formulations of *Metarhizium anisopliae* (Metschnikoff) Sorokin (Deuteromycotina: Hyphomycetes)

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Abstract

Treatments with conidia of the entomopathogenic fungus *Metarhizium anisopliae* formulated in invert emulsion (water-in-oil formulation) or in wheat flour were applied to *Rhyzopertha dominica* adults infesting *Cicer arietinum* grains. The application rates were 4.1×10^5 conidia/cm² of treated area using a concentration of 1.8×10^7 conidia/ml of the invert emulsion and 8.2×10^6 conidia/cm² of treated area using a concentration of 6.5×10^8 conidia/g of the wheat flour formulation. Results have indicated significant mortality ($P < 0.05$) when newly emerged *R. dominica* adults were introduced and then treated with the invert emulsion and wheat flour formulations (86.7–93.3%, control treatment 10.0–26.7% mortality). When treated grains were left until the emergence of F₁ adults, there was also significant mortality ($P < 0.05$) in both treatments (28.3–60.0%, control treatment 1.7–8.3% mortality). This indicates a residual effectiveness of the treatment with the two formulations against *R. dominica* adults which extended to > 2 months (equivalent to the duration of the insect life-cycle at $23 \pm 2^\circ\text{C}$ and $75 \pm 5\%$ r.h.). Infestation rate of *C. arietinum* grains by *R. dominica* at $23 \pm 2^\circ\text{C}$ and $75 \pm 5\%$ r.h. was significantly reduced in the treatments with the fungal conidia formulated in invert emulsion (0.7%) or in wheat flour (1.0%) when compared with the control treatment (19.0–23.3%). The preventive treatments significantly retarded *R. dominica* development ($P < 0.05$) by 8–12 days compared with the control treatment. The infection with the fungus thus delayed adult emergence of *R. dominica* by 8–12 days. Overall results give promise for control of *R. dominica* with *M. anisopliae* mixed with wheat flour or introduced into invert emulsion.

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1. Introduction

The lesser grain borer (*Rhyzopertha dominica* (F.)) is one of the most important insect pests infesting whole, dried, sound grain of many cereals and legumes throughout the world (Hagstrum and Flinn, 1994; Hagstrum et al., 1994). Both adults and larvae of this insect pest are able to attack whole, sound grain. The adult insects are long-lived and lay an average of 1–7 eggs/day over several months. Eggs are laid externally on the grains and larvae, after hatching, bore into and feed inside the grains, then pupate inside the grains and remain inside for several days after eclosion (Hagstrum and Flinn, 1994; Mayhew and Phillips, 1994).

Under conditions in Palestine, stored-grain insect pests including *R. dominica* cause considerable damage in stored grains and their by-products. Losses due to these insect pests have been estimated at 15% or more of total grains stored each year (Palestinian Ministry of Supply, Ramalla, Palestine; pers. comm.). Control of *R. dominica* and other stored-grain insect pests is locally, but irregularly, practised by mixing the grains with powdered formulations of organochlorine insecticides such as chlordane and lindane to decrease the insect damage in storage facilities during warm months. In other countries, insect management plans include chemical control with lindane, malathion, chlorpyrifos-methyl, bioresmethrin, resmethrin, deltamethrin, pirimiphos-methyl, fenitrothion and cyfluthrin (Bengston et al., 1975; Brun and Attia, 1983; Arthur, 1992, 1994; Lorini and Galley, 1999) and the fumigants methyl bromide and phosphine (Attia and Greening, 1981; Tyler et al., 1983; Herron, 1990; Zettler, 1997; Zettler and Arthur, 2000).

Attempts to control *Sitophilus oryzae* (L.), *Tribolium castaneum* (Herbst) and *R. dominica* with the insect pathogen *Beauveria bassiana* (Balsamo) Vuillemin have been reported (Padin et al., 1996, 1997, 2002; Rice and Cogburn, 1999; Dal-Bello et al., 2001). *Metarhizium anisopliae* (Metsch.) Sorokin has been reported less frequently for control of stored-grain insects although studies to date have mainly concerned its use for control of many field insect pests such as locusts and grasshoppers (Prior and Greathead, 1989; Lomer et al., 1997), or beetle larvae (Rath, 1992). It has been used for control of *S. oryzae* on wheat grains by treatment with a suspension of conidia mixed with those of *B. bassiana* (Dal-Bello et al., 2001).

The objectives of the present research were to examine in *R. dominica*, the preventive and curative effects of treatments with conidia of *M. anisopliae* on adult mortality, infestation rate of chickpea (*Cicer arietinum* L.) grains, and duration of life-cycle.

2. Materials and methods

2.1. Insect rearing

Adults of *R. dominica* (strain LGB₁) were reared on dried, healthy, mature, chickpea grains (cultivar: Hadas) in plastic containers (15 cm diameter by 20 cm high) under the insectary conditions ($23 \pm 2^\circ\text{C}$, $75 \pm 5\%$ r.h. and 16 h per day of illumination). The containers were covered with cheese cloth fastened by rubber bands to prevent escape of insects and to ensure proper ventilation. Newly emerged adult insects (males and females) were used in the experiments.

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