Laboratory studies evaluating the insecticidal efficacy of six diatomaceous earth formulations, as structural treatments, against two species of coleoptera

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In all over the world, synthetic pesticides and fumigants like methyl bromide, have traditionally been used to treat the structure of empty grain stores between harvests to control residual pest populations. However, the number of pesticides currently registered for this use is decreasing following concerns over food and environmental safety and development of resistant pest populations. With the continued requirements for free-pest grain, the need to assess alternative compounds is of increasing important. One natural product that has had increasing use in pest control is diatomaceous earth, which composed of fossilized diatoms. Diatomaceous earths (DEs) are very promising alternatives to traditional pesticides with very low mammalian toxicities. In stored-product protection, DEs have proved effective as grain protectants and structural treatments to storage facilities.

Laboratory strains of *Tribolium castaneum* (Herbst) and *Rhyzopertha dominica* (F.) were used in this study. Mixed sex adults of *T.castaneum* and *R.dominica* aged 1-3 weeks old, were used. Beetle species were maintained in a controlled environment (CE) room set at 28 ± 1 $^{0}$C and 65% relative humidity (r.h.) in darkness. Insecolo, PyriSec, SilicoSec, Insecto, InsectoSec and a new DE formulation, DEBBMV-P/WP, were obtained from BIOFA Company (Germany), Hedley Technologies Inc (Canada) and INSECTO Natural Products Inc (USA). Dry dust application of each DE was assessed. Dosage of 5g/m$^2$ of each DE application and an untreated control were assessed, with three replicates of each treatment. In this study, steel panels (0.3 by 0.3 m) were used. For the dry dust application, the require amount of dust was sprinkled evenly over the panels by sieving through a 250 micro meters mesh sieve. The treated surfaces were put into experimental conditions of 28 ± 1 $^{0}$C and 60 ± 2% r.h. overnight before addition of the insects. Thirty insects of each species were then placed into separate plastic rings in each panel and the tops of plastic rings were covered with muslin. Adult mortalities were assessed after 24h, 48h, 7d and 14d of exposure. The mean percentage mortalities were calculated for each pest species and treatments, and were subjected to Arcsin transformation. The transformed data were statistically compared using analysis of variance (ANOVA) at the 5% probability level with individual comparisons made using Duncan`s multiple range test.

Results: Results are showed in table 1 and 2. Insect mortalities increased after periods of time. Against *R.dominica*, after 24 h, the range of mortalities was 42.2-70%, and DEBBM-P/WP caused highest mortality. Only after 7 days, DEBBM-P/WP and PyriSec were the most effective treatments and caused 100% adult mortality. SilicoSec was the second effective treatment with killed 92.2% of *R.dominica* and Insecto caused lowest adult mortality in comparison with other treatments by caused 76.6% adult mortality (Table 1 and 2). Hence, after 14 days there are no significant differences among treatments, exception Insecto with 92.2% adult mortality. Against *T.castaneum*, the same trend was observed. After 24 h, the adult mortality in

DEBBM-P/WP and PyriSec treated surfaces were more than other insecticides and after 7 days, these two DEs cause complete mortality, and other DEs caused 64.4-74.4% adult mortality, respectively.

Table 1. Mean of % adult mortality (±SE) exposed to 24h and 48h, in galvanized steel surfaces treated with six DE formulations.

| Type of DE | Insect Species | | | |
|---|---|---|---|---|
| | *R.dominica* | | *T.castaneum* | |
| | 24 h | 48 h | 24 h | 48 h |
| Insecolo | 45.5 ± 1.69 cd | 61.1 ± 0.65 c | 22.2 ± 0.76 c | 35.5 ± 0.66 c |
| Pyrisec | 64.4 ± 0.66 b | 85.5 ± 0.88 b | 41.1 ± 0.64 b | 62.2 ± 0.64 b |
| Silicosec | 50.0 ± 1.10 c | 64.4 ± 0.66 c | 21.1 ± 0.76 c | 36.6 ± 1.15 c |
| Insecto | 42.2 ± 0.64 d | 54.4 ± 0.64 d | 17.7 ± 0.83 d | 34.4 ± 0.66 c |
| Insectosec | 46.6 ± 1.11 cd | 62.2 ± 0.64 c | 22.2 ± 0.76 c | 34.4 ± 0.66 c |
| DEBBM-P/WP | 70.0 ± 1.21 a | 88.8 ± 1.01 a | 47.7 ± 0.65 a | 66.6 ± 1.18 a |
| Control | 0.0 ± 0.0 e | 0.0 ± 0.0 e | 0.0 ± 0.0 e | 0.0 ± 0.0 d |

Means within an entire column followed by the same letter are not significantly different (P>0.05)

Table 2. Mean of % adult mortality (±SE) exposed to 7d and 14d, in galvanized steel surfaces treated with six DE formulations.

| Type of DE | Insect Species | | | |
|---|---|---|---|---|
| | *R.dominica* | | *T.castaneum* | |
| | 7 d | 14 d | 7 d | 14 d |
| Insecolo | 84.4 ± 0.88 c | 100 ± 0.0 a | 64.4 ± 1.31 c | 92.2 ± 1.15 b |
| Pyrisec | 100 ± 0.0 a | 100 ± 0.0 a | 100 ± 0.0 a | 100 ± 0.0 a |
| Silicosec | 92.2 ± 1.15 b | 100 ± 0.0 a | 74.4 ± 1.42 b | 97.7 ± 4.81 a |
| Insecto | 76.6 ± 1.31 d | 92.2 ± 1.15 b | 65.5 ± 0.66 c | 91.1 ± 1.11 b |
| Insectosec | 85.5 ± 0.88 c | 98.9 ± 3.35 a | 64.4 ± 0.66 c | 90.0 ± 1.87 b |
| DEBBM-P/WP | 100 ± 0.0 a | 100 ± 0.0 a | 100 ± 0.0 a | 100 ± 0.0 a |
| Control | 0.0 ± 0.0 e | 0.0 ± 0.0 c | 0.0 ± 0.0 d | 0.0 ± 0.0 c |

Means within an entire column followed by the same letter are not significantly different (P>0.05).

Even after 14 days, no treatment exception DEBBM-P/WP and PyriSec, could reach 100% adult mortality and other insecticides caused range 90-97.7% respectively. Against two species the DEBBM-P/WP and PyriSec were the most effective treatments, producing 100% adult mortalities in 7 days, compared to the other treatments. As the exposure period increased, however, the surface appeared to break up, probably due to the movement of the insects and more of the DE was picked up.

In the present experiments, the dose of 5g/$m^2$ was effective against two species in storage constructed by steel, and further experiments will need to assess the efficacy of DEs on surfaces such as concrete and wood against the most tolerant insects to provide a more realistic challenge to DE efficacy. Farm-scale trials will also provide information on DE efficacy in the field and allow for dose recommendations to be provided.

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