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Efficacy of "diatomaceous earth" to control the main stored grain pests

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Abstract

To assess the efficacy of "diatomaceous earth" in controlling stored grain pests an experiment was set in the Stored Grain Laboratory of Embrapa Wheat in Passo Fundo, RS, Brazil in 2005. The experimental design was randomized blocks with four treatments replicated three times. Each plot was made of 1.0 kg of organic grain (wheat, barley, maize and beans) treated separately with "diatomaceous earth" (Keepdry and Insecto), infested with 20 adults of each species and stored in a room with 25 ± 1 ºC of temperature and 60 ± 5 % of relative humidity. The "diatomaceous earth" used in wheat grain treatment were Keepdry at 500 and 1,000 g/ton of grain, and Insecto at 1,000 g/ton of grain and tested to control *Sitophilus oryzae* and *Tribolium castaneum.* For maize grain the treatments were Keepdry of 750 and 1,000 g/ton of grain, and Insecto of 1,000 g/ton of grain and tested to control *Sitophilus zeamais;* for black beans the treatments were Keepdry of 250 and 1,000 g/ton of grain, and Insecto of 1,000 g/ton of grain to control *Acanthoscelides obtectus*; and for barley grain the treatments were Keepdry of 500 and 1,000 g/ton of grain, and Insecto of 1,000 g/ton of grain to control *Sitophilus oryzae.* At all four bioassays a control treatment (grain without any treatment) was used to assess the natural mortality of the experiment. After two days of treatment a 100 g sample was taken from each plot and infested with 20 adults of each species separately. Twenty days later the grain was sieved and the number of dead insects was recorded to assess the mortality. The results showed that both insecticide formulations of "diatomaceous earth", Keepdry and Insecto were effective to control stored grain pests at different dosages and types of grain.

Key words: inert dust, pest control, non chemical insecticide, stored grain.

Introduction

Estimates show that about 120 million tons of grain produced annually in Brazil, 20 % is lost in the processes of harvesting, transport and storage (Brazil, 1993). The mean quantity losses caused by stored grain pests, in Brazil, estimated by FAO and by the Brazilian Ministry of Agriculture, Livestock and Food Supply, are of approximately 10.0 % of the total produced annually. This represents about 12 million tons each year. Far more troubling are the quality losses, as they can compromise the usage of the grain produced or even disqualify it for a required standard, resulting in a lower commercial value.

The control of stored grain pests depends mostly on insecticides of broad action aspect and fumigants. Combinations of physical and biological methods can be integrated to increase efficiency in the control of pests, and also to decrease the use of chemical products, the impact

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on beneficial species and costs. Integrated control depends on the understanding of the storing ecosystem, including pest population dynamics and precise methods for monitoring population levels of these pests (Hagstrum and Flinn 1992; Arbogast et al. 1998).

Alternative control methods of stored grain pests are being emphasized so as to reduce the application of insecticides, and so decrease the human exposure potential and the development of insecticide resistant pests (Ebeling,1971). The concern towards insecticide applications and the rising pressure imposed by consumers and scientists to substitute chemical insecticides for less toxic and dangerous agents, have lead to the development of inert dust formulations (Korunic,1998).

The use of inert dust to control stored grain pests is a technique with a long history and has been reviewed by many authors (Ebeling, 1971; Loschiavo, 1988a; b; Shawir et al., 1988; Aldryhim, 1990; 1993). With the advent of synthetic chemicals, this method was neglected, however the problems that chemical insecticides present today, such as control failures, residues in food, pest resistance, etc., are proportioning the return of this efficient method of control of stored grain pests. Commercial formulations of some inert dusts are already in existence. In the United States of America, the "diatomaceous earth" -based silica is generally recognized as safe for human and animal consumption and registered as a food additive (Banks & Fields, 1995). Inert dust, besides being very safe and presenting low toxicity in mammals, does not affect grain baking quality (Ebeling, 1971; Aldryhim, 1990).

"Diatomaceous earth" - based inert dust derives from diatomaceous algae fossils, which naturally possesses a thin silica layer. Dust particles adhere to the insect's body by contact. Inert dust acts by removing the epicuticular wax, causing loss of water and so death by dehydration (Ebeling, 1971; LePatourel, 1986; Aldryhim, 1990; Banks and Fields, 1995; Golob, 1997; Korunic, 1998; Lorini, 2003). It is a user-safe product and of lasting insecticide effect, as it does not lose efficiency along time.

Other inert dusts, such as the silicate compounds, are reported to also have insecticide proprieties (Ebeling, 1971). These are derived from mineralized rocks and can be used in the control of stored grain pests since they have silica in their composition.

Keepdry and Insecto products are two commercial formulations of "diatomaceous earth" -based inert dust, containing 860 and 867 g/kg of silica dioxide, respectively. Both are registered for grain treatment, aiming to control stored grain pests.

The aim of this work is to asses de efficacy of the Keepdry and Insecto insecticides ("diatomaceous earth"), applied at different dosages on stored wheat grain to control *Sitophilus oryzae* and *Tribolium castaneum;* on maize to control *Sitophilus zeamais*, on black beans to control *Acanthoscelides obtectus* and on barley to control *Sitophilus oryzae*.

Material and methods

The experiment was set at the Entomology Laboratory of Embrapa Wheat, in Passo Fundo, RS, Brazil in 2005. The experimental design used was of random blocks, with 4 treatments and 3 replicates. Each experimental plot was composed of 1.0 kg of organic grain, wheat, maize, black beans and barley. The treatments were assembled with two "diatomaceous earth" insecticides, Keepdry and Insecto, at different dosages, both registered in Brazil for controlling stored grain pests, plus a control treatment without insecticide. For each experimental plot, the grain was placed in plastic bags, the insecticide dosage was applied and the grain was manually homogenized for two minutes. Later, the grain was placed in 5.0 kg of capacity paper bags and stored in a room with temperature and relative humidity of 25 ± 1 ºC and 60 ± 5 %, respectively.

Immediately after the treatment, a sample of 100 g of grain was collected from each replicate. The samples were placed in 200 ml of capacity glass jars, in which 20 adult insects of each

species (*S. oryzae, T. castaneum, S. zeamais, A. obtectus*) to be assessed were released separately. These insects came from a laboratory culture from Embrapa Wheat Laboratory. The jars were sealed with filter paper and arboseal and maintained in a room with temperature and relative humidity of 25 ± 1 ºC and 60 ± 5 %, respectively.

The assessment of the adult mortality of each pest-species was made 20 days after infestation, through grain sieving and counting the number of dead insects.

The results were submitted to statistical analyses (ANOVA) and to F test ($p \leq 0.05$). The means were compared between themselves by Tukey test ($p \leq 0.05$).

Results and discussion

Wheat: For the control of both species, *Sitophilus oryzae* and *Tribolium castaneum*, 100 % insect mortality was verified after 20 days of infestation. The two insecticides Keepdry, in both dosages, and Insecto were significantly superior to the control treatment but did not differ statistically from each other (Table 1).

Maize: For the control of the specie *Sitophilus zeamais*, 100 % of insect mortality was verified after 20 days of infestation with Keepdry insecticide and 98 % of insect mortality with Insecto insecticide. The two insecticides Keepdry, in both doses, and Insecto were significantly superior to the control treatment, but did not differ statistically from each other (Table 2).

Beans: For the control of the species *Acanthoscelides obtectus*, 100 % of insect mortality was verified after 10 days of infestation with Keepdry insecticide with the dosage of 1,000 g c.f./t and 80 % of insect mortality with the dosage of 250 g c.f./t of grain. Insecto insecticide showed 70 % of insect mortality. The two insecticides Keepdry, in both doses, and Insecto were significantly superior to the control treatment, but did not differ statistically from each other (Table 3).

Barley: For the control of the species *Sitophilus oryzae*, 100 % insect mortality was verified after 20 days of infestation. The two insecticides Keepdry, in both doses, and Insecto were significantly superior to the control treatment but did not differ from each other

Table 1. Mortality of *Sitophilus oryzae* and *Tribolium castaneum* in stored wheat grain treated with "diatomaceous earth" . Embrapa Wheat, Passo Fundo, RS. 2005.

Treatment	Dosage (g a.i./t)	Dosage (g c.f./t)	*Sitophilus oryzae* No[1]	*Sitophilus oryzae* E[2]	*Tribolium castaneum* No[1]	*Tribolium castaneum* E[2]
Keepdry ("diatomaceous earth")	430	500	20,0 a	100	20,0 a	100
Keepdry ("diatomaceous earth")	860	1000	20,0 a	100	20,0 a	100
Insecto ("diatomaceous earth")	867	1000	20,0 a	100	20,0 a	100
Control	-	0	2,33 b	-	3,67 b	-
CV (%)	-	-	2,19	-	1,85	-

a.i. = active ingredient; c.f. = commercial formulation.

[1] Mean number of dead insects 20 days after infestation with 20 adult insects per replicate.

[2] Mortality percentages compared to control calculated by the formula of Abbott (1925).

Means followed by the same letter in the column do not differ statistically between themselves, by Tukey test ($p \leq 0.05$).

Table 2. Mortality of *Sitophilus zeamais* in stored maize grain treated with "diatomaceous earth" . Embrapa Wheat, Passo Fundo, RS. 2005.

Treatment	Dosage (g a.i./t)	Dosage (g c.f./t)	*Sitophilus zeamais* No[1]	E[2]
Keepdry ("diatomaceous earth")	645	750	19,7 a	98
Keepdry ("diatomaceous earth")	860	1,000	20,0 a	100
Insecto ("diatomaceous earth")	867	1,000	20,0 a	100
Control	-	0	0,0 b	-
CV (%)	-	-	0,91	-

a.i. = active ingredient; c.f. = commercial formulation.
[1] Mean number of dead insects 20 days after infestation with 20 adult insects per replicate.
[2] Mortality percentages compared to control calculated by the formula of Abbott (1925).
Means followed by the same letter in the column do not differ statistically between themselves, by Tukey test ($p \leq 0.05$).

Table 3. Mortality of *Acanthoscelides obtectus* in stored beans grain treated with "diatomaceous earth". Embrapa Wheat, Passo Fundo, RS. 2005.

Treatment	Dosage (g a.i./t)	Dosage (g c.f./t)	*Acanthoscelides obtectus* No[1]	E[2]
Keepdry ("diatomaceous earth")	215	250	8,0 a	80
Keepdry ("diatomaceous earth")	860	1,000	10,0 a	100
Insecto ("diatomaceous earth")	867	1,000	7,0 a	70
Control	-	0	1,3 b	-
CV (%)	-	-	8,20	-

a.i. = active ingredient; c.f. = commercial formulation.
[1] Mean number of dead insects 20 days after infestation with 20 adult insects per replicate.
[2] Mortality percentages compared to control calculated by the formula of Abbott (1925).
Means followed by the same letter in the column do not differ statistically between themselves, by Tukey test ($p \leq 0.05$).

Table 4. Mortality of *Sitophilus oryzae* in stored barley grain treated with "diatomaceous earth" . Embrapa Wheat, Passo Fundo, RS. 2005.

Treatment	Dosage (g a.i./t)	Dosage (g c.f./t)	*Sitophilus oryzae* No[1]	E[2]
Keepdry ("diatomaceous earth")	430	500	20,0 a	100
Keepdry ("diatomaceous earth")	860	1,000	20,0 a	100
Insecto ("diatomaceous earth")	867	1,000	20,0 a	100
Control	-	0	1,0 b	-
CV (%)	-	-	5,96	-

a.i. = active ingredient; c.f. = commercial formulation.
[1] Mean number of dead insects 20 days after infestation with 20 adult insects per replicate.
[2] Mortality percentages compared to control calculated by the formula of Abbott (1925).
Means followed by the same letter in the column do not differ statistically between themselves, by Tukey test ($p \leq 0.05$).

(Table 4).

Considering these results of the pests' mortality by the insecticides during storage it is possible to infer that the "diatomaceous earth" -based insecticides Keepdry and Insecto were efficient on the control of the stored grain pests as *Sitophilus oryzae, Tribolium castaneum, Sitophilus zeamais* and *Acanthoscelides obtectus*, in the dosages varying from 250 to 1,000 g of c.f./t of grain. These insecticides can be used in stored wheat, maize, black beans and barley as grain protectant to avoid the damage caused by the pests described above and maintain grain quality during storage.

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