PS10-22 – 6258

Effectiveness of different dosages of diatomaceous earth to control *Tribolium castaneum* (Coleoptera: Tenebrionidae) in corn stored in the state of Roraima

A.L. Marsaro Junior[1,], M. Mourão Junior[1], P.R.V. da S. Pereira[2], W.R.S.C. de Paiva[3]*

Abstract

Tribolium castaneum is considered a secondary pest of stored corn, but is one of the most important storage pests in Brazil, because when present in grains contributes to contamination and depreciation of the commercial value of the flour obtained from cereals. The use of grain protectants to control this pest in the northern area of Brazil, is rare. In this sense, the objective of this research was to evaluate the effectiveness of a diatomaceous earth, in different dosages, applied in corn stored in Roraima, to control of *T. castaneum*. Grains of the hybrid BRS 1030 were treated with five dosages of diatomaceous earth, 0, 125, 250, 500 and 1,000 g/t. Each treatment, containing 100 g of kernels, was infested with 30 adults of *T. castaneum* and maintained in laboratory at 27 °C. The accumulated mortality was evaluated from the 1st to the 28th day. The mortality of the adults was influenced by the dosages and the exposure time of insects to diatomaceous earth. Logistic models were used to describe the mortality curves. These models were used to estimate the necessary time to obtain 90 and 95 % mortality of the population. In the dosages of 125 and 250 g/t the maximum mortality, obtained after 28 days of exposure, was 30 and 50 %, respectively. In the dosage of 500 g/t the maximum mortality was higher than 95 %, achieved eleven days after treatment, while to the dosage of 1,000 g/t the necessary time to reach the same level of mortality was shorter, three days of exposure. Diatomaceous earth in the dosages of 500 and 1,000 g/t were highly effective to control *T. castaneum*.

Key words: diatomaceous earth, stored product pests, fisical control, corn.

Introduction

Tribolium castaneum is considered a secondary pest of the stored corn, but it is one of the most important storage pests in Brazil, because when present in the grains contributes to the contamination and depreciation of the commercial value of the flour of the cereals. The control of this pest is realized mainly with chemical insecticides. Due to the problem of contamination with residues of insecticides in food, the use of inert dusts, as diatomaceous earth, to control stored product insects, has been studied intensively.

Several studies have already demonstrated the potential of control of the diatomaceous earth on some of the main stored product insects,

[1] Embrapa Roraima, Br 174, Km 8, Distrito Industrial, Mail Box 133, Zip code 69301-970, Boa Vista/RR/Brasil, Fax number (95) 3626 7125, alberto@cpafrr.embrapa.br

[2] Embrapa Trigo, BR 285, km 294, Mail box 451, Zip code 99001-970, Passo Fundo/RS/Brasil

[3] Faculdades Cathedral, Zip code 69307-005, Boa Vista/RR/Brasil

[*]Corresponding author

Oryzaephilus surinamensis (L.) (Coleoptera: Silvanidae) (Arthur, 2001); *Tenebrio molitor* (L.) (Coleoptera: Tenebrionidae) (Mewis & Ulrichs, 2001); *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae) (Arthur, 2002); *Rhyzopertha dominica* (F.) (Coleoptera: Bostrichidae) (Baldassari et. al., 2002); *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae), *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) and *Sitophilus zeamais* (Stathers et. al., 2004); *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae) (Arnaud et al., 2005); *Tribolium confusum* (Herbst) (Coleoptera: Tenebrionidae) (Athanassiou et. al., 2005); *Ephestia kuehniella* Zeller (Lepidoptera: Pyralidae) and *Sitophilus granarius* (L.) (Coleoptera: Curculionidae) (Collins & Coook, 2006) and *Acanthoscelides obtectus* (Say) (Coleoptera: Bruchidae) (Bello et al., 2006).

Diatomaceous earth inert dusts derive from deposits of diatomaceous algae fossils, which possesses a thin silica layer. Small particles of this dust adhere to insect's body and remove the epicuticular wax, causing death by dehydration (Subramanyam & Roesli 2000)

Since the use of grain protectants in the north area of Brazil are rare, the objective of this research was to evaluate the effectiveness of the diatomaceous earth, in different dosages, applied in corn stored in Roraima, to control *T. castaneum.*

Materials and methods

Grains of the hybrid BRS 1030 were treated with five dosages of diatomaceous earth (860 g/kg of silica dioxide), 0, 125, 250, 500 and 1,000 g/t, with 4 replicates. Each treatment, containing 100 g of kernels, maintained in glass bottles, was infested with 30 adults of *T. castaneum* and kept in laboratory at 27 °C. The accumulated mortality was evaluated from the 1st to the 28th day. The mortality observed in the treatments was corrected with the mortality in control (Abbott, 1925).

The model adopted to analyze the data considered the effect of the dosage and the exposure time, to diatomaceous earth, on the mortality of insects. The referring data to the mortality were submitted to the repeated measures ANOVA and the averages compared by the test of Duncan at the level of 5 %. Data were analyzed using the SAS® System (Littel et. al., 1996) and STATISTICA 5.5 (Statsoft Inc., 1999).

The behavior of the mortality, along the time, it was unfolded, in each one of the levels marked as significant in the model, under the application of a non-linear adjustment of the logistic type $y = a/(1 + (x/x_0)^b)$. The adjusted coefficient of determination ($R^2_{aj.}$) was used as an indicator of adherence of the model.

Results

The mortality of *T. castaneum* was influenced by the exposure time of insects to diatomaceous earth ($F_{(5;75)} = 3{,}585$; $p < 0.001$), by the dosages tested ($F_{(4;15)} = 12{,}944$; $p < 0.001$), and also by the interaction among these two factors ($F_{(20;75)} = 972$; $p<0.001$).

It was observed that, in the dosages of 500 and 1000 g/t the accumulated mortality was superior to 95 %, while in the smallest dosages, 125 and 250 g/t, the maximum mortality was of 30 and 50 %, respectively (Figure 1 and Table 1). In the absence of diatomaceous earth, treatment controls, the accumulated maximum mortality during the evaluation period was of 4 %.

The logistic model applied (Table 1) estimated for the dosage of 1,000 g/t a time of 3 days to obtain 90 % of mortality and 9 days for the dosage of 500 g/t, while in the dosages of 125 and 250 g/t the index of 90 % of mortality was not reached, even after 28 days of exposition.

The necessary time to obtain 95 % mortality for the dosage of 1,000 g/t, according to the logistic model, was 3 days and for the dosage of 500 g/t was 11 days, while in the dosages of 125 and 250 g/t the index of 95 % mortality was not reached, even after 28 days of exposition.

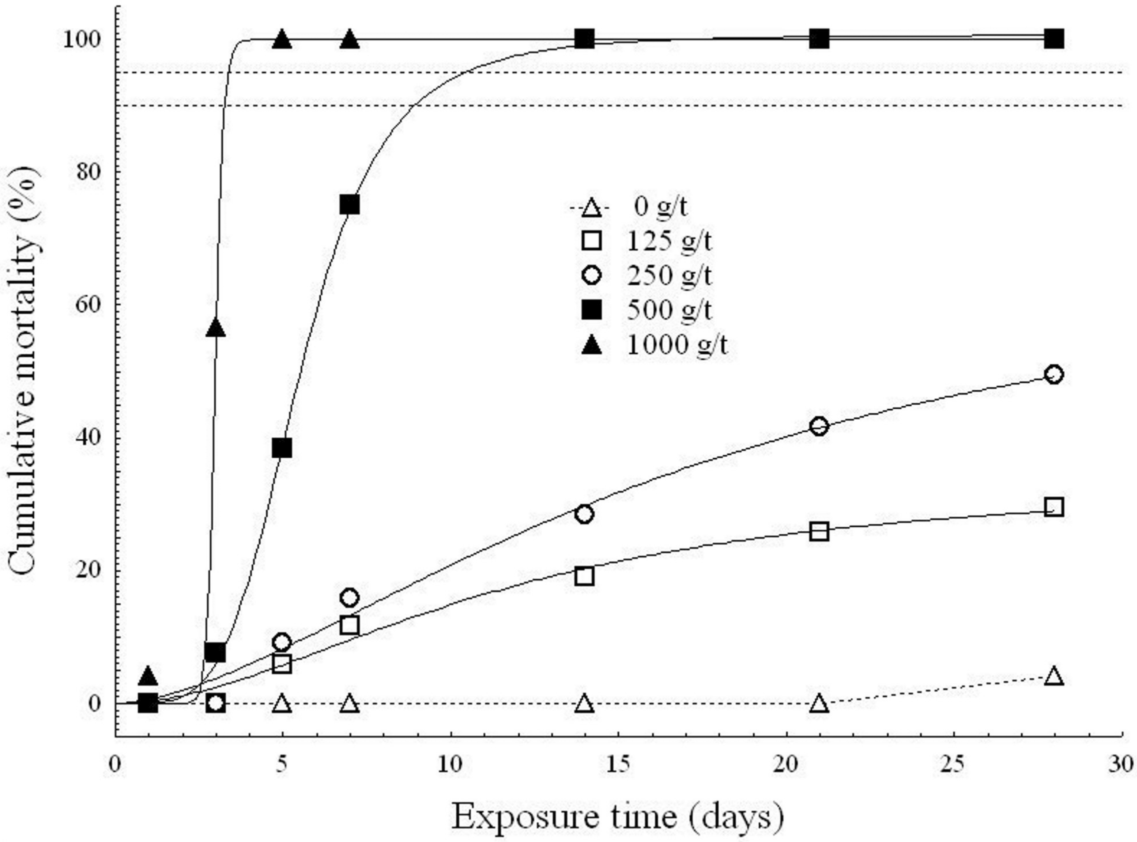

Figure 1. Adjust of the logistic model of the accumulated mortality in function of days of exposure of insects to diatomaceous earth in different dosages.

Table 1. Mean values (%)[a] of accumulated mortality of *Tribolium castaneum* in function of the exposure time of insects to diatomaceous earth and of dosages used of this protectant; and parameters of the logistic model.

	Dosage of diatomaceous earth (g/t)									
Day	0		125		250		500		1000	
1	0	b	0	b	0	b	0	b	4,17	a
3	0	c	0	c	0	c	7.5	b	56,67	a
5	0	e	5.83	d	9.17	c	38.33	b	100	a
7	0	e	11.67	d	15.83	c	75	b	100	a
14	0	d	19.17	c	28.33	b	100	a	100	a
21	0	d	25.83	c	41.67	b	100	a	100	a
28	4.17	d	29.56	c	49.56	b	100	a	100	a
	Parameter of the model									
Coefficient	0		125		250		500		1000	
a	-		0.343		0.705		1.007		1	
b	-		11.488		16.867		5.536		2.967	
X_0	-		-1.91		-1.66		-4.471		-24.044	
$R^2_{aj.}$	-		0.986		0.99		1		0.998	

[a] Values followed by the same letter, in the horizontal, don't differ statistically to each other, by Duncan test (p = 0.05).

Discussion

In the present study, was observed that there was an increase in mortality of *T. castaneum* as the exposure time to diatomaceous earth increased. Dowdy (1999), studying that pest, also verified that the mortality increased with larger periods of exposure of insects to diatomaceous earth. Similar results also were found by Arthur (2001), however the author worked with *O. surinamensis*.

The increase of mortality with the increase of dosages also was verified by Athanassiou et. al. (2005). These authors treated wheat with diatomaceous earth in growing dosages, of 0 up to 1,500 g/t, and verified that there was an increase in mortality of *T. confusum* as the protectant's dosage increased.

The significant interaction between dosage and exposure time in relation to mortality, observed in the present study, was also observed by Arthur (2002) when studying the effects of those two factors on the percentage of adults' survival of *S. oryzae* exposed to wheat treated with diatomaceous earth. Athanassiou et. al. (2005) also observed significant interaction between the exposure time and dosages of diatomaceous earth on the mortality of *S. oryzae* and *T. confusum*.

The low rates of mortality in the lower dosages, 125 and 250 g/t, were also observed by Athanassiou et. al. (2005). Using the dosage of 250 g/t these authors verified mortality levels lower than 20 %, even 7 days after the exposure of the adults of *T. confusum* to diatomaceous earth. Using the dosage of 200 g/t Arnaud et. al. (2005) verified that some populations of *T. castaneum* presented mortality inferior to 10 %, even after 21 days of exposure of insects to the protectant.

In the dosage of 1,000 g/t, 3 days of exposure were necessary to reach 95 % of mortality (Figure 1). Using that same dosage Athanassiou et. al. (2005) also verified mortality above 95 % of the population of *T. confusum*, however 7 days after the exposure to diatomaceous earth.

In the dosage of 500 g/t 11 days were necessary to reach 95 % of mortality of the population of *T. castaneum* (Figure 1). Using the dosage of 500 g/t Athanassiou et. al. (2005) obtained mortality above 95 %, however 7 days after exposure.

Larger periods of exposure of the insects, in the lowest dosages, to reach a satisfactory control of the pests were also verified by Mewis and Ulrichs (2001) and Athanassiou et. al. (2005). That fact is related to the way of action of the product. The death of the insects by the diatomaceous earth is a consequence of the dehydration provoked by the removal of the epicuticular wax from the tegument of the insects (Subramanyam & Roesli, 2000). Therefore, in lower dosages this process occurs more slowly, causing death by dehydration in a larger time, when compared with the highest dosages.

The use of diatomaceous earth besides to control several pests of stored grains still presents the following characteristics, mentioned by Aldryhim (1990), low toxicity to the mammals, doesn't affect the germination of seeds, wheat flour, and baking quality. Besides, this protection of grains is compatible with other control methods in the handling of pests, for instance, the biological control. Bello et. al. (2006) demonstrated that the association of diatomaceous earth with entomopathogenic fungi, to control stored product pests, is possible.

Conclusion

Diatomaceous earth presented high efficiency tocontrol *T. castaneum* only in the highest dosages.

Increasing the dosage of diatomaceous hearth a reduction of the exposure time necessary to cause mortality in the population of insects was observed.

References

Abbott, W.S., 1925. A method of computing the effectiveness of an insecticide. Journal of Economic Entomology 18, 265-267.

Arnaud, L., Lan, H.T.T., Brostaux, Y., Haubruge, E., 2005. Efficacy of diatomaceous earth formulations admixed with grain against of *Tribolium castaneum*. Journal of Stored Products Research 41, 121-130.

Athanassiou, C.G., Vayias, B.J., Dimizas, C.B., Kavallieratos, N.G., Papagregoriou, A.S., Buchelos, C.T., 2005. 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. Journal of Stored Products Research 41, 47-55.

Aldryhim, Y.N., 1990. Efficacy of the amorphous silica dust, dryacide, against *Tribolium confusum* Duv. and *Sitophilus granarius* (L.) (Coleoptera: Tenebrionidae and Curculionidae). Journal of Stored Products Research 26, 207-210.

Arthur, F.H., 2001. Immediate and delayed mortality of *Oryzaephilus surinamensis* (L.) exposed on wheat treated with diatomaceous earth: effects of temperature, relative humidity, and exposure interval. Journal of Stored Products Research 37, 13-21.

Arthur, F.H., 2002. Survival of *Sitophilus oryzae* (L.) on wheat treated with diatomaceous earth: impact of biological and environmental parameters on product efficacy. Journal of Stored Products Research 38, 305-313.

Baldassari, N., Baldoni, G., Baronio, P., 2002. Efficacy of different diatomaceous earths to control adult insects. Tecnica Molitoria 53, 1201-1207.

Bello, G., Padin, S., Juarez, P., Pedrini, N., Giusto, M., 2006. Biocontrol of *Acanthoscelides obtectus* and S*itophilus oryzae* with diatomaceous earth and *Beauveria bassiana* on stored grains. Biocontrol Science and Technology 16, 215-220.

Collins, D.A., Cook, D.A., 2006. Laboratory evaluation of diatomaceous earths, when applied as dry dust and slurries to wooden surfaces, against stored-product insect and mite pests. Journal of Stored Products Research 42, 197-206.

Dowdy, A.K., 1999. Mortality of red flour beetle, *Tribolium castaneum* (Coleoptera: Tenebrionidae) exposed to high temperature and diatomaceous earth combinations. Journal of Stored Products Research 35, 175-182.

Littel, R.C., Miliken, G.A., Stroup, W.W., Wolfinger, R.D., 1996. SAS® System for Mixed Models. SAS Institute Inc., Cary.

Mewis, I., Ulrichs, C., 2001. Action of amorphous diatomaceous earth against different stages of the stored product pests *Tribolium confusum*, Tenebrio molitor, *Sitophilus granarius* and Plodia interpunctella. Journal of Stored Products Research 37, 153-164.

Stathers, T.E., Denniff, M., Golob, P., 2004. The efficacy and persistence of diatomaceous earth admixed with commodity against four tropical stored product beetle pests. Journal of Stored Products Research 40, 113-123.

Statsoft, Inc., 1999. STATISTICA for Windows [Computer program manual]. StatSoft, Inc., Tulsa. http://www.statsoft.com.

Subramanyam, B., Roelsi, R., 2000. Inert dusts. In: Subramanyam, B., Hagstrum, D.W. (Eds.), Alternatives to pesticides in stored-product IPM. Kluwer Academic Publishers, Norwell, pp. 321-380.