PS10-21 – 6256

Effectiveness of different dosages of diatomaceous earth to control *Sitophilus zeamais* (Coleoptera: Curculionidae) in corn stored in the state of Roraima

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Abstract

The maize weevil, *Sitophilus zeamais*, is one of the major pests of stored corn in Brazil. The control of this pest is done mainly with chemical insecticides. The use of grain protectants in the northern area of Brazil is rare. In this sense, the objective of this research was to evaluate the effectiveness of diatomaceous earth, in different dosages, applied in corn stored in Roraima, to control *S. zeamais*. Grains of the hybrid BRS 1001 were treated with six dosages of diatomaceous earth, 0, 200, 400, 600, 800 and 1,000 g/t. Each treatment, containing 100 g of kernels, was infested with 30 adults of *S. zeamais* and maintained in laboratory at 27 °C. Accumulated mortality was evaluated from the 1st to the 28th day. The mortality of adults was influenced by the dosages and the exposure time of insects to diatomaceous earth. Logistic models were used to describe mortality curves. These models were used to estimate the necessary time to obtain 90 and 95 % mortality of the population. The dosages of 1,000 and 800 g/t reached 95 % of mortality 5 and 6 days after treatment, respectively, while 600 and 400 g/t took 9 and 12 days, respectively, to reach the same level of mortality. In the dosage of 200 g/t the maximum mortality was 91 % after 28 days of exposure. Diatomaceous earth in the dosages of 800 and 1,000 g/t presented a high effectiveness to control *S. zeamais* in a short space of time.

Key words: diatomaceous earth, maize weevil, fisical control, corn.

Introduction

The maize weevil, *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae), is one of the major pests of stored corn in Brazil. 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 a lot.

Several studies have already demonstrated the potential of control of diatomaceous earth on some of the principal stored product insects, *Sitophilus granarius* (L.) (Coleoptera: Curculionidae) (Aldryhim, 1990); *Oryzaephilus surinamensis* (L.) (Coleoptera: Silvanidae) (Arthur, 2001); *Plodia interpunctella* (Hubner) (Lepidoptera: Pyralidae) (Mewis and Ulrichs,

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2001); *Rhyzopertha dominica* (F.) (Coleoptera: Bostrichidae) (Baldassari et. al., 2002); *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae), *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) and *S. zeamais* (Stathers et. al., 2004); *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae) (Arnaud et al., 2005); *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae) (Athanassiou et. al., 2005a); Acanthoscelides obtectus (Say) (Coleoptera: Bruchidae) (Bello et al., 2006) and *Ephestia kuehniella* Zeller (Lepidoptera: Pyralidae) (Collins and Coook, 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).

The use of grain protectants in the north area of Brazil is rare. In this sense, the objective of this research was to evaluate the effectiveness of diatomaceous earth, in different dosages, applied in corn stored in Roraima, to control of *S. zeamais.*

Materials and methods

Grains of the hybrid BRS 1001 were treated with six dosages of diatomaceous earth (860 g/kg of silica dioxide), 0, 200, 400, 600, 800 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 *S. zeamais* 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, 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 *S. zeamais* was influenced by the exposure time of insects to diatomaceous earth ($F_{(5;90)}$ = 10,710; $p < 0.001$), by the dosages tested ($F_{(5;18)}$ = 28,484; $p < 0.001$), and also by the interaction among these two factors ($F_{(25; 90)}$ = 702; $p < 0.001$).

It was observed that, in the dosages of 400, 600, 800 and 1,000 g/t the accumulated mortality was superior of 95 %, while in the smallest used dosage, 200 g/t, the mortality was close to 90 % (Figure 1 and Table 1). In the absence of diatomaceous earth, treatment controls, the accumulated maximum mortality during the evaluation period was of 2,5 %.

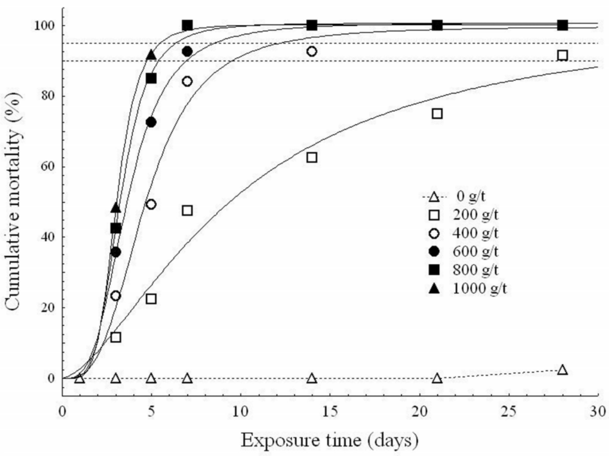

Figure 1. Adjust of the logistic model of the accumulated mortality in function of days of exposure of insects to diatomaceous earth in different dosages.

Table 1. Mean values (%)[a] of accumulated mortality of *Sitophilus zeamais* 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		200		400		600		800		1000	
1	0	a	0	a	0	a	0	a	0	a	0	a
3	0	f	11.67	e	23.33	d	35.83	c	42.5	b	48.33	a
5	0	f	22.5	e	49.17	d	72.5	c	85	b	91.67	a
7	0	e	47.5	d	84.17	c	92.5	b	100	a	100	a
14	0	d	62.5	c	92.5	b	100	a	100	a	100	a
21	0	c	75	b	100	a	100	a	100	a	100	a
28	2,5	c	91.45	b	100	a	100	a	100	a	100	a
	Parameter of the model											
Coefficient	0		200		400		600		800		1000	
a	-		1.031		0.998		1.008		1.007		1.003	
b	-		9.724		4.667		3.639		3.244		3.047	
x_0	-		-1.586		-3.12		-3.284		-4.206		-4.907	
$R^2_{aj.}$	-		0.9762		0.9894		0.9986		0.9985		0.9997	

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

The logistic model used (Table 1) estimated a time to obtain 90 % of mortality for the dosage of 1,000 g/t of 4 days, for the dosage of 800 g/t of 5 days, while in the dosages of 600 and 400 g/t were necessary seven and ten days, respectively. In the smallest dosage, 200 g/t, were necessary 30 days.

The necessary time to obtain 95 % of mortality for the dosage of 1,000 g/t, according to the logistic model, was 5 days, for the dosage of 800 g/t was 6 days, while the dosages of 600 and 400 g/t were necessary nine and twelve days, respectively.

Discussion

In the present study, was observed an increase in the mortality of *S. zeamais* as the exposure time of the insect to diatomaceous earth increased. Arthur (2001) also verified that behavior when studying the effect of diatomaceous earth in the mortality of *O. surinamensis*. Similar results also were found by Athanassiou et al. (2005a), however the authors worked with the pest *S. oryzae*.

The increase in the mortality of the insects with the increase of the dosages also was verified by Aldryhim (1990). The author treated wheat with diatomaceous earth in growing dosages, of 0 up to 1,000 g/t, and verified that there was a reduction of the progeny of *S. granarius* as the protectant's dosage increased.

The significant interaction between the dosage and the exposure time, related with the mortality of the insects, observed in the present study, was also observed by Arthur (2002) when the author studied the effects of those two factors on the percentage of adults' survival of *S. oryzae* exposed to wheat treated with diatomaceous earth.

The high rates of mortality of the insects, even in the smallest dosages, 200 and 400 g/t, also were observed by Arthur (2002). Using the dosage of 300 g/t, the author verified mortality superior to 82 % after a week of exposure of the insects to diatomaceous earth. Using the dosage of 200 g/t

Arnaud et. al. (2005) verified mortality of the population of *T. castaneum* superior to 95 %, after 21 days of exposure, however the authors also verified differences in the effectiveness of the diatomaceous earth due to differences in the origin of populations of the pest and in the diatomaceous earth formulations.

In the dosage of 1,000 g/t, to reach 95 % of mortality, 5 days of exposure of the insects to diatomaceous earth were necessary (Figure 1). Using the same dosage Athanassiou et. al. (2005a) also verified mortality above 95 % of the population of *S. oryzae*, however after 7 days of exposure to diatomaceous earth.

In the dosage of 600 g/t 9 days of exposure were necessary to reach 95 % of mortality of the population of *S. zeamais* (Figure 1). Using the dosage of 500 g/t Athanassiou et. al. (2005a) obtained mortality above 95%, however after 7 days of exposure.

Athanassiou et. al. (2005a) also verified that, in the lowest dosages, to reach a satisfactory level of control of the pests, a larger period of exposure was needed. This fact is related to the mode of action of diatomaceous earth in the insect. According to Subramanyam & Roesli (2000) the death of the insects by diatomaceous earth is attributed to the dehydration provoked by the abrasiveness of the small particles of this inert dust and by adsorption of oils in the body of the insect, which breaks the layer of wax on the epicuticle, causing loss of water and death. Therefore, in higher dosages the adsorption of wax and abrasiveness caused by the product occurs more quickly, causing death in a shorter time, when compared with the lower dosages.

Products composed by diatomaceous earth usually delay a little more to kill insects, when compared to neurotoxic insecticides that act for contact, however, the residual effect of the diatomaceous earth is usually larger. Studies led by Athanassiou et al. (2005b) demonstrated that the diatomaceous earth caused more than 90 % of mortality of the population of *S. oryzae* in wheat treated with this protectant over a period of 270 days.

Conclusion

Diatomaceous earth showed great efficiency to control *S. zeamais* in all dosages tested.

As the dosage of diatomaceous earth increased a reduction in the exposure time necessary to reach high levels of mortality 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., 2005a. 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.

Athanassiou, C.G., Kavallieratos, N.G., Economou, L.P., Dimizas, C.B., Vayias, B.J., Tomanovic, S., Milutinovic, M., 2005b. Persistence and efficacy of three diatomaceous earth formulation against *Sitophilus oryzae* (Coleoptera: Curculionidae) on wheat and barley. Journal of Economic Entomology 98, 1404-1412.

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 *Sitophilus 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.

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.