PS7-21 – 6205

Diatomaceous earth and propionic acid to control *Sitophilus oryzae* and *Oryzaephilus surinamensis* rice stored grain pests

A. Morás[1], F.M. Pereira[2,7], M. de Oliveira[3,7], I. Lorini[4], M.A. Schirmer[5,7], M.C. Elias[6,7]*

Abstract

The use of inert dust and carbonic organic acid alone or combined may be an alternative method to control stored grain pests. The aim of these studies was to assess the insecticide effect of diatomaceous earth and propionic acid alone or combined for the control of stored grain pests in rice. The "agulhinha" rice grain (*Oryza sativa* L.) class was used. A complete randomized design of 13 treatments, replicated three times, was set-up with two diatomaceous earth products, Keepdry and Bugram in three dosages each, two dosages of propionic acid, and four combination of diatomaceous earth and propionic acid, and a control. Samples of grain were collected at 2, 4, 8 and 12 months, after treatment and infested with 20 adult insects of each species of *Sitophilus oryzae and Oryzaephilus surinamensis*. The mortality assessment of insects was recorded after 30 days of infestation. The diatomaceous earth treatments were effective to control the storage grain pests after twelve months of storage. The propionic acid alone was not effective to control the pests but the combination with diatomaceous earth showed to be efficient in grain conservation and rice quality.

Key words: rice, diatomaceous earth, propionic acid, grain quality, stored grain pests.

Introduction

The search for an economic, feasible, healthy and environmentally safe solution for the conservation of stored grain is a challenge for agricultural and agro-industrial researchers.

The insects that attack stored grain are a problem, mainly because of the quality and quantity losses they cause, but also because of the control methods used, which are highly toxic chemical products that can cause pest resistance (Lorini, 2003). The use of inert dust and short carbonic chain organic acids, applied alone or combined, is an alternative method to the use of chemicals. Diatomaceous earth-based inert dust, an abrasive and hygroscopic product derived

[1] Biologist, M.Sc., Technical Supervisor of GP/Vetquímica. Rua Livramento, 456, CEP: 99025-500 Passo Fundo, RS, Brazil. E-mail: alexamoras@yahoo.com.br

[2] Agronomyst Ing., Science and Technology Agroindustry Graduating Master.

[3] Agronomy student, CNPq PIBIC research

[4] Brazilian Agricultural Research Corporation (EMBRAPA), National Wheat Research Centre (Embrapa Wheat). Rodovia, BR 285, KM 294, CEP 99001-970, Passo Fundo, RS, Brazil E-mail: ilorini@cnpt.embrapa.br

[5] Chemestry, Dr. Associated Professor

[6] Agronomyst Ing., Dr. Titular Professor, CNPq PQ research .

[7] Post-harvest and Industrial Grain Laboratory, Science and Technology Industry Department. Agronomy Faculty. Federal University of Pelotas. Phone: +55 53 3275 7258. Campus Universitário, UFPel, Caixa Postal 354, CEP 96010-900, Capão do Leão, RS. Brazil. E-mail: eliasmc@ufpel.tche.br

* Corresponding author.

from diatomaceous algae fossils, acts by removing the insect's epicuticular wax, causing loss of water, and so death by dehydration (Lorini et al., 2003).

Organic acids and their esters are substances diffused in nature as intermediary or final vegetable, animal and microorganism products. These substances are used in grain conservation due to their antimicrobial proprieties. The antimicrobial activities of the organic acids and their derived esters is due to the action of non-dissociated molecular form of these substances in the cellular content of the grain and associated organisms (Cramel and Prestegard, 1977; Baird-Parker, 1980; Kung et al., 2004).

The aim in this study was to asses the efficiency of Keepdry and Bugram inert dust, alone or combined with propionic acid, on the control of the main stored rice pests.

Materials and methods

The grain was dried and stored in the Post Harvest and Grain Quality Laboratory of DCTA, FAEM and UFPEL, where the acid and inert dust dosages were applied. The selection, rearing, infestation and treatment insecticide assessment took place at the Entomology Laboratory of Embrapa Wheat, in Passo Fundo, RS.

The experimental design used was completely randomized with thirteen treatments and three replicates each one with 30 kg of rice. The treatments consisted in different dosages of diatomaceous earth-based inert dust of two commercial formulations as shown on Table 1.

Samples of the rice grain were taken at 2, 4, 8, and 12 months during the storage period. To asses the pests' mortality 300g grain samples were taken from each replicate, and placed in glass jars, in which 20 adult insects of the species *Sitophilus oryzae* and O*ryzaephilus surinamensis* where released separately. These insects came from a laboratory culture from Entomology Laboratory of Embrapa Wheat. 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 30 days after infestation through grain sieving and counting the number of dead insects, and then calculating the mortality percentage.

The results were submitted to statistical analyses and to F test ($p \leq 0.05$). The means were compared between themselves by Tukey test ($p \leq 0.05$). The software used was SAS Institute (Coimbra et al., 2004).

Table 1. Rice stored grain treatments of diatomaceous earth and propionic acid used in the experiment to control stored grain pests *Sitophilus oryzae* and O*ryzaephilus surinamensis*.

Treatment	Commercial formulation	Dosage (kg/ton of grain)
01	Keepdry	0.5
02	Keepdry	1.0
03	Keepdry	1.5
04	Bugram	1.0
05	Bugram	2.0
06	Bugram	3.0
07	Propionic Acid	0.3
08	Propionic Acid	0.6
09	Keepdry + Propionic Acid	1.0 + 0.3
10	Keepdry + Propionic Acid	1.0 + 0.6
11	Bugram + Propionic Acid	2.0 + 0.3
12	Bugram + Propionic Acid	2.0 + 0.6
13	Control treatment	-

Results and discussion

The results (Tables 2 and 3) showed that the mortality percentage of the rice pests can be controlled by the diatomaceous earth treatment, assessed at different periods during one year of storage.

Generally, higher temperatures make the insects move more upon the grain mass, thus, the possibility of contact with inert dust particles is higher, also higher temperatures increase water loss, which is positively related with the efficacy of diatomaceous earth (Subramanyam and Roesli, 2000; Arthur, 2001; Stathers et al., 2002).

According to Fields and Korunic (2000), adequate exposure time is crucial for diatomaceous earth effectiveness. It's supposed that insect movement increases cuticle contact with dust particles, however part of the insect's mobility and susceptibility are influenced by cuticle characteristics. In this case, the insect exposure time with treated rice grain was of 30 days.

Table 2 shows the mortality results of *Sitophilus oryzae* and it is evident that all treatments were statistically superior to the control, except the treatments with propionic acid at the 2, 4 and 8 months assessment.

All doses of Keepdry product were efficient on the control of this pest not differing statistically between themselves. The same occurred with all doses of Bugram presenting a high mortality rate.

The two doses of propionic acid tested did not have a good performance as insecticide. The combinations of acid and inert dust presented a high mortality rate for the two commercial formulations assessed.

According to Stathers et al. (2002) the mortality of *Sitophilus zeamais* increased with diatomaceous earth grain treatment, the insecticide effect persisted during the experiment

Table 2. Insecticide effect of different dosages of inert dust and propionic acid, alone or combined, in the control of *Sitophilus oryzae*, in rice grain assessed by the mean of dead insects per plot, expressed in mortality percentage.

Treatment	Dosage (kg/ton)	Storage Month 2	4	8	12
Keepdry	0.5	77.50 ab	81.25 a	80.00 a	100.00 a
Keepdry	1.0	97.50 a	92.50 a	100.00 a	100.00 a
Keepdry	1.5	100.00 a	95.00 a	100.00 a	100.00 a
Bugram	1.0	97.50 a	98.75 a	98.75 a	100.00 a
Bugram	2.0	97.50 a	98.75 a	100.00 a	100.00 a
Bugram	3.0	98.75 a	100.00 a	100.00 a	100.00 a
Propionic Acid	0.3	11.25 c	11.25 b	11.25 b	91.25 a
Propionic Acid	0.6	61.25 b	20.00 b	5.00 b	86.25 a
Keepdry + Propionic Acid	1.0 + 0.3	87.50 ab	96.25 a	75.00 a	100.00 a
Keepdry + Propionic Acid	1.0 + 0.6	96.25 a	93.75 a	73.75 a	100.00 a
Bugram + Propionic Acid	2.0 + 0.3	100.00 a	100.00 a	100.00 a	100.00 a
Bugram + Propionic Acid	2.0 + 0.6	100.00 a	95.00 a	100.00 a	100.00 a
Control treatment	-	0.00 d	10.00 b	5.00 b	33.75 b
C.V. %		8.50	9.16	8.40	4.16

Means followed by the same letter, in the column, do not differ statistically between themselves by the Tukey test ($p \leq 0.05$). Infestation of 20 adult insects per plot.

Table 3 Insecticide effect of different dosages of inert dust and propionic acid, alone or combined, in the control of *Oryzaephilus surinamensis*, in rice grain assessed by the mean of dead insects per plot expressed in mortality percentage.

Treatment	Dose (kg/ton)	Storage Month 2	4	8	12
Keepdry	0.5	100.00 a	100.00 a	97.50 a	100.00 a
Keepdry	1.0	100.00 a	100.00 a	100.00 a	100.00 a
Keepdry	1.5	100.00 a	100.00 a	100.00 a	100.00 a
Bugram	1.0	100.00 a	100.00 a	98.75 a	100.00 a
Bugram	2.0	100.00 a	100.00 a	100.00 a	100.00 a
Bugram	3.0	100.00 a	100.00 a	100.00 a	100.00 a
Propionic Acid	0.3	100.00 a	95.00 a	47.50 bc	87.50 a
Propionic Acid	0.6	100.00 a	100.00 a	28.75 c	96.25 a
Keepdry + Propionic Acid	1.0 + 0.3	100.00 a	100.00 a	91.25 a	100.00 a
Keepdry + Propionic Acid	1.0 + 0.6	100.00 a	100.00 a	77.50 ab	100.00 a
Bugram + Propionic Acid	2.0 + 0.3	100.00 a	100.00 a	100.00 a	100.00 a
Bugram + Propionic Acid	2.0 + 0.6	100.00 a	100.00 a	100.00 a	100.00 a
Control treatment	-	95.00 a	78.75 b	27.50 c	66.25 b
C.V. %		1.00	3.43	9.02	3.57

Means followed by the same letter, in the column, do not differ statistically between themselves by the Tukey test ($p \leq 0.05$). Infestation of 20 adult insects per plot.

and the mortality effect is dose-dependent.

Athanassiou et al. (2003) reports that *Sitophilus oryzae* mortality increases according to the pests' exposure time to diatomaceous treated grain. Studies made by Arthur (2002) with *Sitophilus oryzae* show that this pest is more susceptible to diatomaceous earth treatment exposure compared with other assessed pests and also that the mortality rate depends partially on the grain temperature and/or moisture content.

For the *Oryzaephilus surinamensis* species as shown on Table 3 Keepdry and Bugram treatments permitted the control of this pest showing high mortality rate.

Golob (1997) reports that there is no clearness in the available literature as to the susceptibility of *O. surinamensis* to diatomaceous earth formulations. According to the author this pest is more susceptible when compared with *S. oryzae* e *Rhyzopertha dominica*. According to Arthur (2001) *O. surinamensis* is more susceptible to the diatomaceous earth formulation tested in his study.

The insecticide effect of the propionic acid has not been proved, only its effect in grain conservation against microorganism although treatments with propionic acid showed a high mortality rate of *O. surinamensis*. It's supposed that propionic acid has an insect repellent effect, in this manner preventing them from attacking the grain as reported by other authors with other grain species (Forlin, 1991; Caldasso, 1998).

As with the other species assessed in the experiment combinations of propionic acid and inert dust showed a high mortality rate for this insect in both dosages of the tested products.

As observed in this research's results, we can infer that: the diatomaceous earth formulations, Keepdry and Bugram, were efficient on the control of the main stored rice pests; all tested dosages (0.5, 1.0 and 1.5 kg/ton of grain for Keepdry, and 1.0, 2.0 and 3.0 kg/ton of grain for Bugram) were efficient; propionic acid used alone was not efficient on the control of rice pests during the 12 months of storage although it exerted a small deleterious effect on the pests.

Acknowledgments

The senior author thanks the National Council for Scientific and Technological Development (CNPq), CAPES, SCT-RS (Pólo de Inovação Tecnológica da Região Sul), Embrapa Wheat, COREDE-SUL, ABIAP and the private companies Rio Deserto Mineração e Pesquisa Brasileira Ltda., Vetquímica, GP Representações and Keepdry, for providing laboratory facilities and support for this study.

References

Arthur, F.H., 2001. Immediate and delayer mortality of *Oryzaephilus surinamensis* (L.) exposed on wheat trated 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.

Athanassiou, C.G., Kavallieratos, N.G., Tsaganou, F.C., Vayias, B.J., Dimizas, C.B., Buchelos, C.Th., 2003. Effect of grain type on the insecticidal efficacy of SilicoSec against *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae). Crop Protection 22, 1141-1147.

Baird-Parker, A.C., 1980. Ácidos Orgânicos. In: International Commission on Microbiological Specifications for Foods. Ecologia Microbiana de los Alimentos. Zaragoza, ACRIBIA. p.132-42.

Caldasso, L.H., 1998. Ácidos orgânicos e sistemas de armazenamento na conservação de milho em pequena escala. Pelotas: UFPel, 68p. (Dissertação de Mestrado).

Coimbra, J.L.M., Carvalho, F.I.F., Oliveira, A.C., 2004. Fundamentos do SAS aplicado à experimentação agrícola. Pelotas: UFPel, 236p.

Cramel, J.A., Prestegard, J.H., 1977. Studies of pH induced transport of carboxilic acid across phospholipid vesicle membranes. Biochemical and Biophysical Research Communications 75, 259-301.

Fields, P., Korunic, Z., 2000. The effect of grain moisture content and temperature on the efficacy of diatomaceous earths from different geographical locations against stored-products beetles. Journal of Stored Products Research 36, 1-13.

Forlin, F.J., 1991. Conservabilidade de grãos de sorgo granífero (*Sorghum bicolor* L.), armazenados com umidade de colheita e incorporação de ácidos orgânicos, nos sistemas convencional, granel e hermético. Pelotas, 1991. 162p. Dissertação. (Mestrado em Ciência e Tecnologia Agroindustrial) – Faculdade de Agronomia "Eliseu Maciel", UFPel.

Golob, P., 1997. Current status and future perspectives for inert dusts for control of stored product insects. Journal of Stored Production Research 33, 69-79.

Kung Jr, L., Myers, C.L., Neylon, J.M., Taylor, C.C., Lazartic, J., Mills, J.A., Whiter, A.G., 2004. The Effects of Buffered Propionic Acid-Based Additives Alone or Combined with Microbial Inoculation on the Fermentation of High Moisture Corn and Whole-Crop Barley. Journal Dairy Science 87, 1310-1316.

Lorini, I., 2003. Manual técnico para o manejo integrado de pragas de grãos de cereais armazenados. Passo Fundo: Embrapa Trigo. 80p.

Lorini, I., Morás, A., Beckel, H., 2002. Pós Inertes no Controle das Principais Pragas de Grãos Armazenados. Passo Fundo: Embrapa Trigo. (Boletim de Pesquisa e Desenvolvimento, 8).

Stathers, T.E., Denniff, M., Golob, P., 2002. 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.

Subramanyam, Bh., Roesli, R., 2000. Inert dusts. In: Subramanyam, Bh., Hagstrum, D. W. (Ed.), Alternatives to Pesticides in Stored-Products IPM. Kluwer Academic Publishers 321-380.