Scientific Papers. Series A. Agronomy, Vol. LVII, 2014
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

INFLUENCE OF GRAIN TYPE ON THE EFFICACY OF SOME FORMULATIONS OF DIATOMACEOUS EARTH AGAINST THE RICE WEEVIL (*Sitophilus oryzae* L.)

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Abstract

The paper aimed to present the effect of grain type on the insecticidal efficacy of the diatomaceous earth (DE) formulations, applied on wheat, barley, maize and paddy rice against adults of the rice weevil, Sitophilus oryzae L. *The formulations used in the bioassays were two local DEs deposits from Romania (Buzău Valey-Pătârlagele and South of Dobroudja-Adamclisi), two from Greece (Elassona region) and two comercial products (SilicoSec and PyriSec). The bioassays were done in laboratory conditions set at 25°C and 60±5%relative humidity in 3 series with 3 replicates. The DEs were applied at the dose rates of 100, 300, 500 and 900 ppm (mg DE per Kg of grain), while mortality of the exposed adults was recorded after 7, 14 and 21 days of exposure. Among the tested DEs, the most effective of all, was the commercial formulation of PyriSec witch manage to total control the adults of S. oryzae in half of the tested grains (wheat and maize) after 7 days of exposure in dose rates above 100 ppm. Between the tested grains, DEs were most effective when applied on wheat and totally ineffective on paddy rice. Furthermore for wheat, the two DEs from Romania and one from Greece (Elassona 1), at the highest dose rate, had the same high performance with the commercial formulation of SilicoSec, while for the other grains all of the no commercial DEs was ineffective and performed the same with SilicoSec formulation. These findings lead us to conclude that our no commercial DEs are competitive with the SilicoSec formulation, and can sufficient protect wheat in doses above 900 ppm.*

Key words*: diatomaceous earth, Sitophilus oryzae, stored grains (wheat, barley, rice, maize).*

INTRODUCTION

The use of diatomaceous earths (DEs), a naturally silicaceous dust formed by the fossilized remains of unicellular algae species namely diatoms, represents a promising alternative to chemical insecticides in stored-product protection. For a while, DE was intensively investigated for stored product protections (Korunic, 1998; Athanassiou et al., 2003, 2004, 2005; Kavallieratos et al., 2005).
DE has a several advantages above traditional grain protectants, because it has low mammalian toxicity, does not break down rapidly and does not affect end-use product quality (Korunic, 1998), it can be applied to the commodity with approximately the same technology as traditional residual insecticides, and can provide long-term protection against insects pest (Athanassiou et al., 2005).
Deposits from south-eastern Europe appeared to be very effective against stored grain infested with coleopterons species such as the rice weevil, *Sitophilus oryzae* L., which is a cosmopolitan pest, considered to be one of the most destructive and widespread species in stored grains. Several researchers have investigated local DEs formulations (Rojht et al., 2010; Vayias et al., 2009).
In this context, the paper presents the results obtained in the trials with Romanian and Greek formulations of DEs from local deposits. This research work was carried out in Bilateral Cooperation Project Romania-Greece.

MATERIALS AND METHODS

Diatomaceous Earth Formulations
The amorphous DE samples from two local DEs deposits from Romania (Buzău Valey-Pătârlagele and South of Dobroudja-

Adamclisi), named PatRom and AdRom respectinely, and two others from Greece (Elassona region) were processed at the University of Thessaly in Greece. DEs samples were dried to 3-5% moisture content (m.c.). Then, the moist, soft small pieces were dried in a ventilated oven set at 40°C for 24 h. After drying, small pieces were ground in a laboratory mill at full speed for 10 sec. All samples were shifted through a standard sieve of 100 meshes. The obtained formulations were compared in the trials with commercial products SilicoSec (Biofa, Germany) and PyriSec (Agrinova, Germany). SilicoSec contains approx. 90% SiO_2, while PyriSec contains SilicoSec with natural pyrethrum and piperonyl butoxide.

Commodities

DEs formulations were tested in different grains, since the DE efficacy is determined by the type of the commodity. The grains used were wheat, barley, maize and paddy rice. Wheat, barley and maize were produced in 2012 in Mizil surroundings (latitude 45° 0' 0'' N and longitude 26° 25' 25'' E, about 130 m above sea level). Wheat cultivar was Miranda and barley cultivar was Laverda. Corn hybrid was Fundulea 322. The paddy rice (var. Melas) provenience was Greek. The grains were left previously for 7 days at the appropriate conditions to equilibrate with the desired relative humidity level.

Insects and bioassays

The rice weevil (*Sitophilus oryzae* L.) adults which were used for the trials were taken from a population that was kept in the Laboratory for Entomology of the Research Development Institute for Plant Protection Bucharest.

The bioassays were carried out in laboratory conditions, in 3 series with 3 replicates. The DEs were applied in 1 kg lots of each at the dose rates of 100, 300, 500 and 900 ppm (mg DE per kg of grain). The lots were placed in glass jars, and shaken manually for approx. 3 min. to achieve equal distribution of the DE dust to the entire grain mass. Untreated lot of grains were used, which served as a control. Then, 3 samples (replicates), of 50 g each, were taken from each lot, and these samples were placed in small glass vials, which were closed, apart from a 1.5 cm hole at the top, covered with fine mesh for ventilation. After that, 30 adults (<21 days old) were placed in each vial. The lots were placed in controlled room at temperature of 25°C, and relative humidity level of 60±5%. Mortality in DE-treated commodities was recorded after 7, 14 and 21 days of exposure.

Data analysis

The data were analysed by using the software Graph Pad Prism 5. Adult mortality data were corrected using Abbott's formula (Abbott, 1925). Adult mortality was analysed separately for each grain.

RESULTS AND DISCUSSIONS

Insecticidal efficacy of DE is highly influenced by several factors such as the type of commodity to which it is applied (Athanassiou et al., 2003) and the origin or formulation (Korunic, 2013). The results of our study are presented in the graph from Figures 1-12.

The insecticidal efficacy of DE is determined by the degree of adherence to the kernel, a physical characteristic of each type of grain (Korunic, 1997, 1998).

In Figures 1-3 it can be seen, that mortality of *S. oryzae* adults exposed to treated maize was low, with only exception the mortality levels of PyriSec. Mortality of the exposed adults did not exceed 20% in all dose rates and exposure intervals for the two Romanian and Greek DEs, as well as for SilicoSec. On the other hand, for the improved formulation of PyriSec which additionally contains natural pyrethrum, mortality level was high and the adults totally controlled after 7 days of exposure from dose rates above 100 ppm. Our findings for PyriSec stand in accordance with the work done by Athanassiou and Kavallieratos (2005). The reduced efficacy of DEs applied on maize was also reported from Chintzoglou et al. (2008) for spinosad dust, and can be partially explained with the characteristics of the external surface of the maize, which is smooth and probably reduced retention of the dust particles.

Figures 4-6 present the mortality levels of *S. oryzae* adults exposed on paddy rice treated with all dose rates of DEs. With the exception of PyriSec, where mortality reached 90% in the two higher doses, all the others DEs were ineffective. For paddy rice treated with SilicoSec, Athanassiou et al. (2003) reported

that doses above 1000 ppm needed for a satisfactory level of control of *S.oryzae*

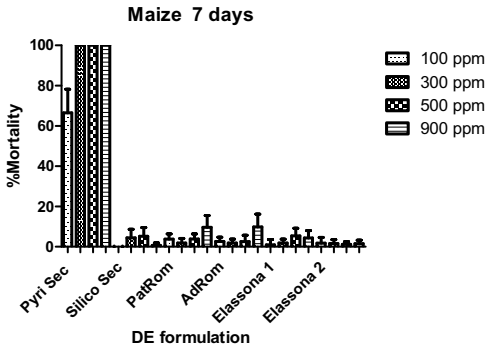

Figure 1. Mortality of *S. oryzae* adults on maize treated with DEs from different origins in four dose rates, at 7 days

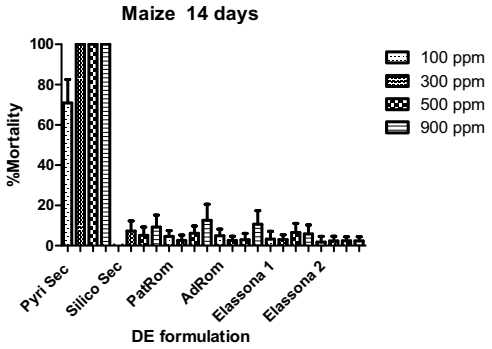

Figure 2. Mortality of *S. oryzae* adults on maize treated with DEs from different origins in four dose rates, at 14 days

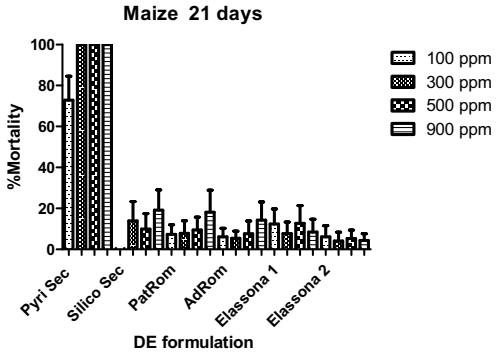

Figure 3. Mortality of *S. oryzae* adults on maize treated with DEs from different origins in four dose rates, at 21 days

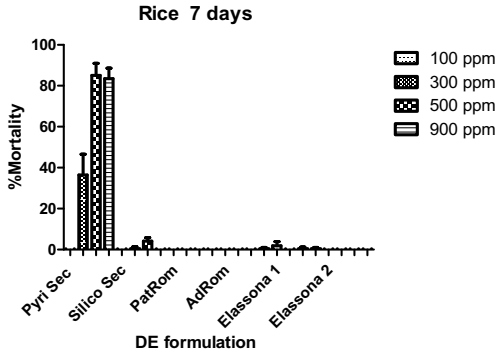

Figure 4. Mortality of *S. oryzae* adults on rice treated with DEs from different origins in four dose rates, at 7 days

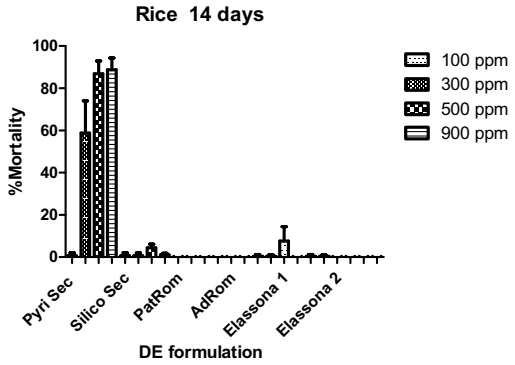

Figure 5. Mortality of *S. oryzae* adults on rice treated with DEs from different origins in four dose rates, at 14 days

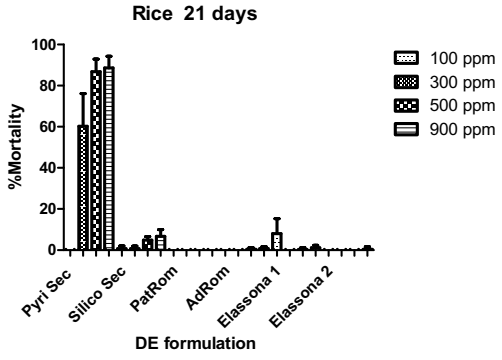

Figure 6. Mortality of *S. oryzae* adults on rice treated with DEs from different origins in four dose rates, at 21 days

In our case the highest dose was 900 ppm which can partially explain this reduced efficacy. Reduced efficacy on paddy rice, as compared to wheat was also reported from Vassilakos and Athanassiou (2013) for the spinosyn-based insecticide spinetoram.
In Figures 7-9, it becomes evident that the most effective was PyriSec, with mortality levels close to 80% after 7 days of exposure at the dose rates of 300, 500 and 900 ppm.

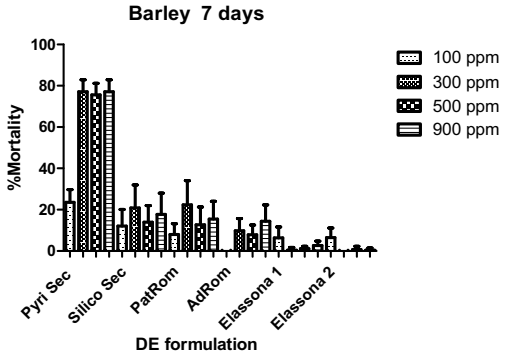

Figure 7. Mortality of *S. oryzae* adults on barley treated with DEs from different origins in four dose rates, at 7 days

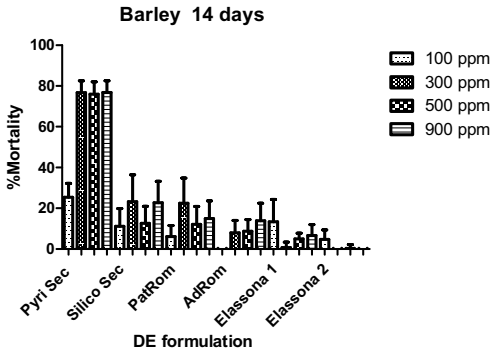

Figure 8. Mortality of *S. oryzae* adults on barley treated with DEs from different origins in four dose rates, at 14 days

The reduced efficacy of PyriSec on peeled barley against *Rhyzopertha dominica* (F.) (Coleoptera: Bostrychidae) was also reported from Athanassiou and Kavallieratos (2005). From the other DEs tested, mortality levels were close to 60%, and achieved only in the highest dose of the commercial formulation SilicoSec, while the DEs from Romania and Greece had the same reduced efficacy. For SilicoSec applied on barley, Athanassiou et al. (2003) reported complete control of *S. oryzae* adults for doses above 1000 ppm. Consequently, higher doses are needed for the control of this species.

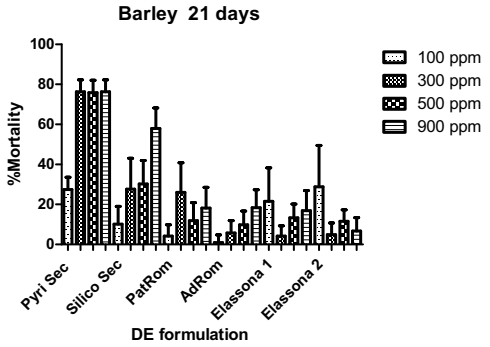

Figure 9. Mortality of *S. oryzae* adults on barley treated with DEs from different origins in four dose rates, at 21 days

Mortality of *S. oryzae* adults on wheat treated with DEs in different dose rates is presented in Figures 10-12. For this grain, DEs were more effective compared to the other substrates tested. PyriSec totally controlled *S. oryzae* adults after 7 days of exposure at 300, 500 and 900 ppm; at the lowest dose mortality reached 100% only after 21 days of exposure. For the other commercial formulation, SilicoSec, mortality increased with the increase of exposure. After 21 days mortality was 100% at the highest dose and above 95% for the doses of 300 and 500 ppm, while at 100 ppm the DE was ineffective.

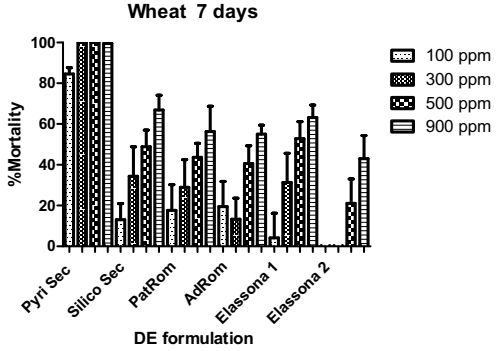

Figure 10. Mortality of *S. oryzae* adults on wheat treated with DEs from different origins in four dose rates, at 7 days

From the Romanian and Greek DEs and for the two higher doses, the two DEs from Romania and one from Greece (Elassona 1) had the same efficacy. Mortality levels for these DE were close to 100% at the highest dose and above 80% for the dose of 500 ppm. At 300 ppm higher mortality levels (above 65%) recorded for PatRom and Elassona 1. Wheat kernels, seems to have greater adherence ability which maybe explains the differences in efficacy, in comparison with the other grains (Athanassiou and Kavallieratos, 2005).

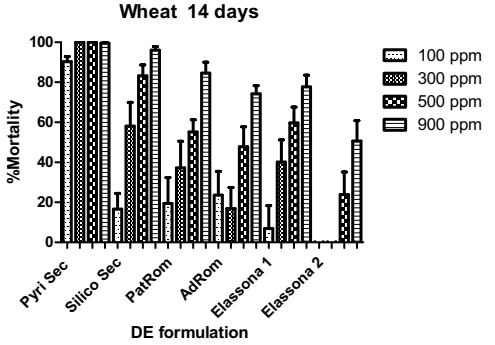

Figure 11. Mortality of *S. oryzae* adults on wheat treated with DEs from different origins in four dose rates, at 14 days

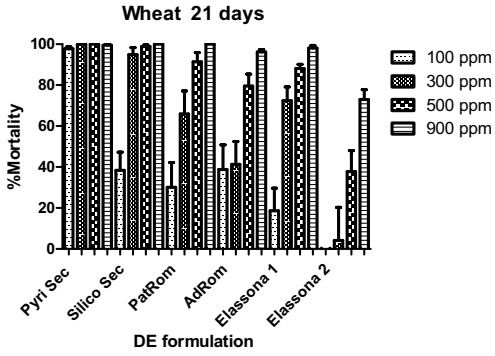

Figure 12. Mortality of *S. oryzae* adults on wheat treated with DEs from different origins in four dose rates, at 21 days

CONCLUSIONS

Based on our results, among the tested DEs, the most effective, was the commercial formulation PyriSec which totally controlled *S. oryzae* adults, in half of the tested grains (wheat and maize) after 7 days of exposure in dose rates above 100 ppm. Among the tested grains, DEs were most effective on wheat and totally ineffective on paddy rice. Furthermore for wheat, the two DEs from Romania and the one from Greece (Elassona 1), at the highest dose rate, had the same performance with the commercial formulation of SilicoSec. Hence, some of the natural DE deposits tested here are comparable with SilicoSec, but further experimentation with higher doses rates and adherence ability are needed to clarify this hypothesis.

ACKNOWLEDGMENTS

This project was supported by the bilateral project "Development of diatomaceous earth-based formulations from natural deposits from Greece and Romania, for stored-product protection against insects and mycotoxins" (General Secretary for Research and Technology, Greece, EPANII/ESPA, UEFISCDI Romania, Bilateral Projects between Greece and Romania).

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