

INSECTICIDAL EFFECT OF SOME INERT DUSTS AGAINST THREE OF STORED GRAIN INSECTS AT MONOFEYA GOVERNORATE

El-Sayed, Ferial M. A.; H. M. El-Zun; A. M Abd El-latif; Salwa M.S. Ahmed and H.B.H Hussain.

Stored Product Pests Res. Dept., Plant Protection Res. Inst., Agric. Res. Center, Dokki, Egypt.

ABSTRACT

Laboratory and field studies were conducted to evaluate the effect of three inert dusts, diatomaceous earth, kaolin and katelsous as wheat grain protectants against some stored grain *Sitophilus oryzae*, *Rhizopertha domininca* and *Tribolium confusum*. Inert dusts were mixed with wheat grain in the laboratory at different concentrations. The LC₅₀'s of diatomaceous earth, kaolin and katelsous were 0.234, 0.071 and 0.235% w/w, 6.033, 6.306 and 8.938% w/w and 0.495, 0.496 and 103.875% w/w against *S. oryzae*, *R. dominica* and *T. confusum*, respectively one day after treatment. Diatomaceous earth was more effective than the other tested materials as it achieved complete mortality for the three tested insects after two days of treatment at the rate of 0.5% w/w. Results also showed that kaolin and katelsous act slowly on the tested insects, where the higher rates of 8% w/w for kaolin and 0.4% w/w for katelsous gave complete mortality one week post treatment. For the field study (at farmers' storages), the higher concentrations (0.5, 8 and 0.4% w/w) of the three dusts, diatomaceous earth, kaolin and katelsous, respectively were admixed with wheat grain and stored for 6 months at the farms. The results showed that diatomaceous earth gave 100%, 84.4% and 93.3% mortality against the three tested insects, respectively after 6 months of storage at a concentration of 0.5% w/w at 7th day of exposure. Kaolin at 8% w/w showed that adult mortality decreased from 100% at zero time of storage after 5 days of exposure to 10.0%, 5.0% and 15.0% at 6 months of storage after the same period of exposure against the three tested insects, respectively. At zero time of storage, katelsous at a rate of 0.4% w/w showed the percent mortalities of 100%, 100% and 95.7% against the three tested insects, respectively at 5 days of exposure. The residual effect after 6 months of storage decreased to 13.0%, 35.0% and 22.0% mortality against the three insects, respectively at 7 days of exposure. In general, the results obtained showed that the diatomaceous earth was the most effective followed by katelsous and kaolin against the three tested insects. Also, the degree of effectiveness decreased with the increasing of storage periods.

INTRODUCTION

Synthetic insecticides have been used since the 1950_s to control stored-product insects (Subramanyan and Hagstrum 1995). However, because of increasing concern over worker exposure, reduced efficacy due to resistant insect populations, pesticide residues in human and animal food, and environment protection, alternative methods are needed to control stored-products insects. As an alternative to chemical control, diatomaceous-earth (DE) has been increasingly used over the last decade and is recognized as essential component of Integrated Pest Management (IPM) in

stored-products Management (Korunic, 1999). DE is a soft rock that is the fossilized remains of unicellular algae called diatoms. Depending upon geological source, it is almost pure amorphous. (IARC, 1997). Diatomaceous earth was as effective as Actellic Super™ Dust but required higher doses. Diatomaceous earth acted faster on *S. zeamais* and *P. subdepressus* compared to *T. castaneum*. The highest dose tested for DE caused the same mortality in *T. castaneum* as the recommended dose of Actellic Super™ Dust. (Mamadou *et al* 2014). Waqas *et al*(2013) studied the effects of combining thiamethoxam at 0.25, 0.5 and 0.75 mg/kg of active ingredient with the diatomaceous earth (DE) formulation. Thiamethoxam alone was more effective at the high dose rate than DE alone, but after 14 days of exposure in most cases, there was greater mortality with DE than with the low dose of thiamethoxam. DE absorbs the insect cuticular waxes which causes death from desiccation and abrades the cuticle (Ebeling, 1971., Rigaux *et al.*, 2001). Inert dusts can be classified into different groups depending on their composition and particle size. Non-silica dust and those composed of coarser grain silicates, such as kaolin have been used traditionally as grain protectants by small-scale farmers in the developing world (Golob, 1997). The toxicity of acid-activated kaolin to adult population of *Sitophilus oryzae*, *Sitophilus zeamais*, *Tribolium castaneum*, *Cryptolestes pusillus*, *Oryzaephilus surinamensis* and *Rhyzopertha dominica* was assessed by admixing the material with paddy (Permul and Patourel 1990). Katelsous has been tested as a carrier dust for conventional insecticides in Egypt (Mostafa and Al-Moagel, 1989). The flour beetle, *T. confusum*, rice weevil, *S. oryzae* and lesser grain borer, *R. dominica* are three of major insect pests of stored grain in Egypt. The rice weevil, *S. oryzae* (L.) is a very serious pest of stored grain. This species infests kernels of various cereals (wheat, barley, rice, and maize), the female oviposits inside the kernel and larvae develop inside the grain kernel till adult completion (Ungsunantwiwat and Mills, 1985, Baker, 1988, Rees, 1996). For the control of this species, fumigants or residual insecticides are usually applied. However, *S. oryzae* has developed resistance to various insecticides in several parts of the world (Champ and dyte, 1976, Arthur, 1996). The insecticidal efficacy of several DE formulations against this species has been discussed by several researchers, (i.e., Quarles, 1992, Korunic, 1999, El-Lakwah *et al*, 2001, Arnoud *et al*, 2005, El-Sayed, *et al*, 2010, Waqas *et al*, 2013 and Mamadou *et al*, 2014.) particularly during the past decade, *R. dominica* cause great damage to grain in storage (El-Nahal *et al.*, 1982 and Daglish *et al.*, 1996). Therefore, the present study was conducted to evaluate the effect of three inert dusts, DE, kaolin and katelsous against three stored wheat insects, *S. oryzae*, *R. dominica* and *T. confusum* at the middle delta region of Egypt, at Monofeya governorate, under the supervision of the regional council for research and agriculture extension, ARC, Ministry of agriculture.

MATERIALS AND METHODS

The present work was conducted to evaluate the efficacy of three inert dusts, diatomaceous earth, Kaolin and Katelsous as wheat protectants in laboratory and field experiments at Monofeya governorate, Egypt against three stored wheat insects, i.e., *Sitophilus oryzae*, *Rhizopertha dominica* and *Tribolium confusum*.

Materials used :

Inert dusts :

- **Diatomaceous earth (D.E.):**
 - Commercial name : Protect-it (D.E. 90%)
 - Bulk density: 0.15 gm/cm³
 - Source: It was purchased from Agrokaslet Co., Canada
- **Kaolin :**
 - Kaolin is a hydrated aluminum silicate.
 - It is fine white or grayish-white, insoluble in water and in organic solvents, and odorless.
 - Source: It was purchased from El-Masria for Chemical and Farm Co., Egypt (Adwia).
- **Katelsous :**
 - It consists of triple phosphate rock 84% and sulphur 16%.
 - Bulk density : 0.70 gm/cm³
 - Source: It was purchased from El-Masria for Seeds, Oils, Chemicals (korm) Co., Egypt.

Insects tested :

The original strains of all tested insects were obtained from the Department of Stored Product Pests, Plant protection Research Institute, Agricultural Research Center, Dokki, Egypt. Insect species were tested and their life cycles were identified according to the method mentioned by Badawy and Doraeham (1991).

Rice weevil, *Sitophilus oryzae* (L.) (Fam. Curculionidae)

The adults of rice weevil, *S. oryzae* were reared on wheat grains under the laboratory conditions of $26 \pm 1^\circ\text{C}$, $65 \pm 5\%$ R.H. Insects were maintained in small glass jars, each contained 100 gm of wheat grains and 200-300 adult insects. Adults were left for two weeks for egg laying in the jars and were then removed. After two weeks, new insects were collected by sieving the culture to using for experiments.

Lesser grain borer, *Rhizopertha dominica* (F.) (Fam. Bostrichidae):

About 300 adults were added to a mixture of 150 gm wheat kernels and 10gm wheat flour in small jar and covered with muslin. Jars were maintained under conditions of $34 \pm 3^\circ\text{C}$ and 70 ± 1 R.H. Adults were left for two weeks for egg laying in the jars and were then removed. After two weeks, newly insects were collected by sieving and were used for experimentation.

Flour beetle, *Tribolium confusum*(H.) (Fam. Tenebrionidae):

T. confusum were cultured in the laboratory and reared in small jar on a mixture of whole wheat flour enriched with beer's yeast (10:1w/w) as

rearing medium and kept in the dark at $30 \pm 3^\circ\text{C}$ and $65 \pm 5\%$ R.H. Adults were left for two weeks for egg laying in the jars and were then removed. After two weeks, new adult emerged were collected by sieving and were used for experimentation.

Preparation of grains and determination of their moisture content:

Wheat grains, *Triticum aestivum*,(Var.) Sakha 61, were used as a rearing medium, for the tested insects. Grains were sterilized by freezing at -18°C for 1 week to kill off any prior infestation. The moisture contents of these grains were measured by oven-drying duplicate samples each of 5 gm, at 130°C for 1 hour. The grains were stored in sealed polyethylene bags in a refrigerator at 5°C till required for experiments.

Methods :

Laboratory experiment :

Series of concentrations of different dusts were prepared by admixing a certain weight of the dust to 100 gm. of wheat grains in one pound glass jar to obtain the desired concentrations, for diatomaceous earth, Kaolin and Katelsous rates of 0.1, 0.2, 0.3, 0.4 gm./100 gm wheat, 1, 2, 4 and 8 gm./100 gm wheat, and 0.05, 0.1, 0.2 and 0.4 gm./100 gm wheat were used respectively.

Dusts were admixed thoroughly with grains to be completely homogenous. Thirty of newly emerged adults of each species (0-3 days old) were introduced to every glass jar and three replicates were made at each concentration level. Control groups were carried out following the same technique. After 1,2,3,5 and 7 days of exposure periods, the average mortality percentages counts were recorded and corrected by Abbott formula(1925). Regression lines were plotted on log-probit paper and data were statistically analysed by suitable methods.

Storage (Field) experiment :

To study the residual activity of the used grain protectants, diatomaceous earth (with rate of 0.5% w/w), Kaolin (with rate of 8% w/w) and Katelsous (with rate of 0.4% w/w), batches of 7 Kg of wheat grains were treated with the mentioned rates. Untreated 7 kg were used as a control. All treatments (treated and control) were kept at storages of farmers in three replicates for every dust. Monthly samples were drawn for 6 months. One kg for every replicate was taken after thorough mixing in the laboratory and divided into several sets, each set consists of 3 replicates. Twenty newly emerged adults of *S. oryzae*, *R. dominica* and *T. confusum* were introduced into glass jar at 26°C and 60-70% R.H. Mortality counts were recorded daily until all insects died. Series of jars with the same technique were used for the control under the same conditions.

RESULTS AND DISCUSSION

Insecticidal activity of the tested dusts (Laboratory experiment) :

Three inert dusts, diatomaceous earth, kaolin and katelsous were evaluated against *S. oryzae*, *R. dominica* and *T. confusum* at different rates of applications. Dusts gave different percentages of mortalities which varied

according to the concentrations and exposure periods. Tables (1, 2 and 3) indicated the following results:

a. Diatomaceous earth (DE):

1. The concentrations of 0.1 and 0.2% w/w of diatomaceous earth gave low mortality (16.7, 32.0%) after one day of exposure, while achieved 86.0% at the concentration of 0.5% w/w against *S. oryzae*. At the same time, mortality obtained after 2 days of exposure, ranged from 86.7 to 100% with the all tested concentrations against the all tested insects (Table 1).
2. The concentration of 0.5% w/w gave 100.0% mortality after 2 days of exposure, against the three tested insects (Table 1).
3. Diatomaceous earth when used against *T. confusum* resulted in gradually increase in percentages of mortality reached to 78.9% one day after treatment at 0.5% w/w (Table 1). Arnoud *et al.* (2005) reached the same results when found that (DE) at a concentration up to 400 ppm was highly effective formulation to control red flour beetle populations.

The results in Tables (4,5 and 6) (Fig 1,2 and 3) showed that the *R. dominica* was more susceptible to DE(LC₅₀ : 0.071%w/w) than of *S. oryzae* or *T. confusum* (LC₅₀ : 0.234 and 0.235%w/w), respectively.

These results are in agreement with those of Athanassiou *et al.* (2007), who found that when three forms of DE were used alone or in combination, they were less effective against *T. confusum* in comparison with the other two species (*S. oryzae* and *R. dominica*).

It is apparent from Table(1) that the rate of 0.5% w/w of DE could be recommended for protection of wheat grains whereas it gave a complete mortality to the three tested insects after 2 days of exposure.

Table (1): Initial toxicity of diatomaceous-earth against *S. oryzae*, *R. dominica* and *T. confusum*.

Concentration (% W/W)	Treated insect	%Mortality after the indicated exposure period (day)	
		1	2
0.1	<i>S. oryzae</i>	16.7	95.6
0.2		32.0	97.8
0.3		62.2	100
0.4		80.0	100
0.5		86.0	100
0.1	<i>R. dominica</i>	68.3	100
0.2		73.3	100
0.3		88.3	100
0.4		90.0	100
0.5		96.7	100
0.1	<i>T. confusum</i>	18.9	86.7
0.2		41.0	93.0
0.3		63.3	97.8
0.4		70.0	100
0.5		78.9	100

b. Kaolin :

It is obvious from Table (2) that the percentage of mortalities increased gradually 3 days after treatment against the three tested insects . The mortality percentages were 15.0, 11.1 and 14.5% at the rate of 1% w/w

kaolin, it reached 91.6, 92.2 and 96.5% at the rate of 8% w/w against *S. oryzae*, *R. dominica* and *T. confusum*, respectively after 3 days of exposure (Table 2).

On the other hand, results obtained in Tables(4-6), Fig (1-3) showed that *T. confusum* was more tolerant than the two other insects according to the LC₅₀s of the three tested insects. These results are in agreement with those of Permual and Patourel (1990) who found that *T. confusum* and *S. oryzae* were relatively tolerant when exposed for 72 hrs. on paddy treated with activated kaolin.

The rate of 8% w/w gave more than 90% mortality after three days of exposure for the three tested insects. Complete mortality was achieved after 7 days of exposure (Table 2). Therefore, the rate of 8% w/w of kaolin dust could be highly recommended for further field studies under natural environmental conditions to assess its protective and persistence capacity.

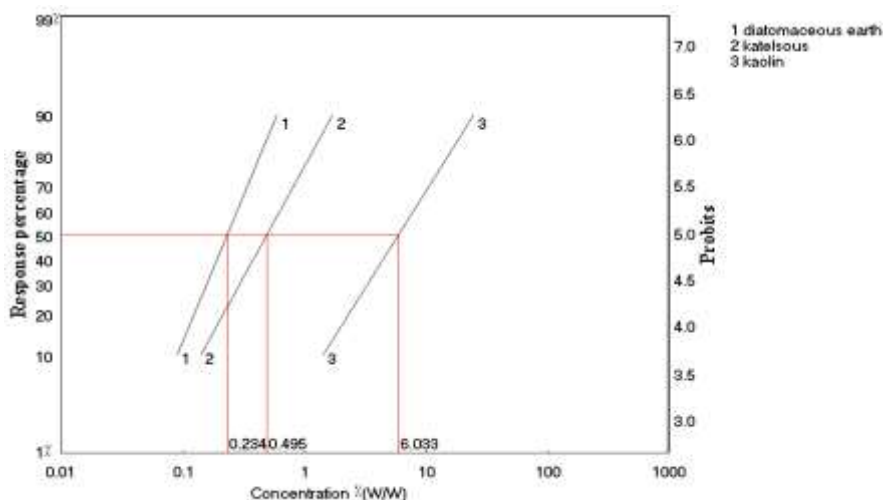


Fig. 1 : Probit regression lines for the toxicity of the tested inert dusts against adults of rice weevil, *S. oryzae* (L) after 24 hrs. exposure to treated wheat grains.

Table (2): Initial toxicity of kaolin against *S. oryzae*, *R. dominica* and *T. confusum*.

Concentration % W/W)	Treated insect	%Mortality after the indicated exposure period day)			
		1	3	7	14
1	<i>S. oryzae</i>	6.7	15.0	95.2	100
2		15.5	31.7	100	100
4		31.0	56.7	100	100
8		63.3	91.6	100	100
1	<i>R. dominica</i>	2.3	11.1	58.2	100
2		4.4	22.2	60.7	100
4		27.7	60.0	91.0	100
8		63.3	92.2	100	100
1	<i>T. confusum</i>	1.0	14.5	90.0	97.5
2		11.7	34.4	91.6	100
4		24.7	65.5	92.8	100
8		44.4	96.5	100	100

Table (3): Initial toxicity of katelsous against *S. oryzae*, *R. dominica* and *T.confusum*.

Concentration (% W/W)	Treated insect	%Mortality after the indicated exposure period (day)			
		1	3	7	14
0.05	<i>S. oryzae</i>	0.0	17.6	83.5	100
0.1		4.0	51.5	89.5	100
0.2		20.0	83.5	100	100
0.4		40.0	89.7	100	100
0.05	<i>R. dominica</i>	0.0	28.0	75.7	100
0.1		9.3	50.7	87.7	100
0.2		18.7	78.7	90.7	100
0.4		44.0	89.3	100	100
0.05	<i>T. confusum</i>	0.0	24.0	77.2	100
0.1		1.0	48.0	88.5	100
0.2		1.7	57.3	94.3	100
0.4		3.1	82.8	95.7	100

Table (4): Toxicity of the tested inert dusts against adults of rice weevil, *S.oryzae* (L.),after exposure to treated wheat grains for 24 hrs.

Inert Dust	LC ₅₀ (%W/W)		LC ₉₀ (%W/W)		Slope	Relative potency ⁽¹⁾ (%)
	Value	Fiducial limits	Value	Fiducial limits		
Diatomaceous earth	0.234	0.21 – 0.26	0.60	0.52 – 0.74	3.12	100.00
Kaoline	6.033	5.06 – 7.60	25.05	17.07 – 45.22	2.07	3.81
Katelsous	0.495	0.40 – 0.73	1.72	1.05 – 4.43	2.37	46.00

⁽¹⁾Relative potency = (LC₅₀ of the most toxic insecticide / LC₅₀ of the candidate insecticide) × 100

Table (5) : Toxicity of the tested inert dusts against adults of lesser grain borer, *Rhizopertha dominica* (F.), after exposure to treated wheat grains for 24 hrs.

Inert Dust	LC ₅₀ (%W/W)		LC ₉₀ (%W/W)		Slope	Relative potency ⁽¹⁾ (%)
	Value	Fiducial limits	Value	Fiducial limits		
Diatomaceous earth	0.071	0.05 – 0.09	0.43	0.34 – 0.59	1.65	100.00
Kaoline	6.306	5.52 – 7.44	17.16	13.23 – 25.15	2.95	1.11
Katelsous	0.496	0.38 – 0.79	2.16	1.19 – 7.33	2.01	14.00

⁽¹⁾Relative potency = (LC₅₀ of the most toxic insecticide / LC₅₀ of the candidate insecticide) × 100

Table (6): Toxicity of the tested inert dusts against adults of red flour beetle, *Tribolium confusum*. (H.), after exposure to treated wheat grains for 24 hrs.

Inert Dust	LC ₅₀ (%W/W)		LC ₉₀ (%W/W)		Slope	Relative potency ⁽¹⁾ (%)
	Value	Fiducial limits	Value	Fiducial limits		
Diatomaceous earth	0.235	0.21 – 0.26	0.66	0.58 – 0.80	2.85	100.00
Kaoline	8.938	7.13 – 12.55	37.93	23.38 – 84.51	2.04	2.85
Katelsous	103.875	83.09 – 140.52	4691.71	2981.31 – 6651.22	0.77	0.23

⁽¹⁾Relative potency = (LC50 of the most toxic insecticide / LC50 of the candidate insecticide) × 100

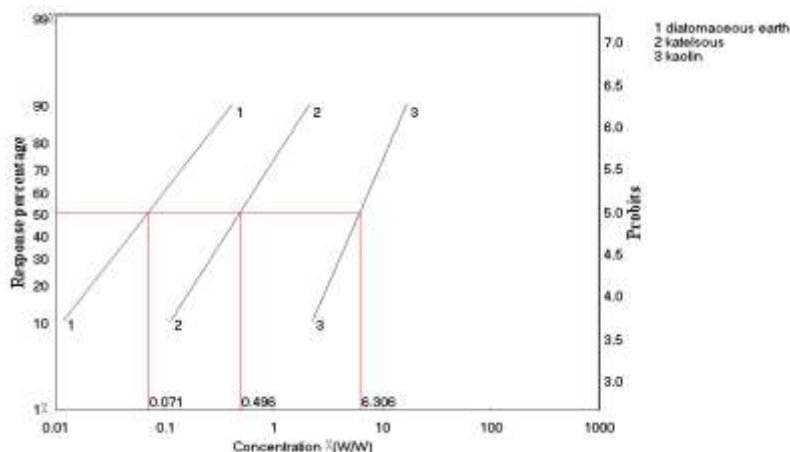


Fig.2 : Probit regression lines for the toxicity of the tested inert dusts against adults of lesser grain borer, *R. dominica* (F) after 24 hrs. exposure to treated wheat grains.

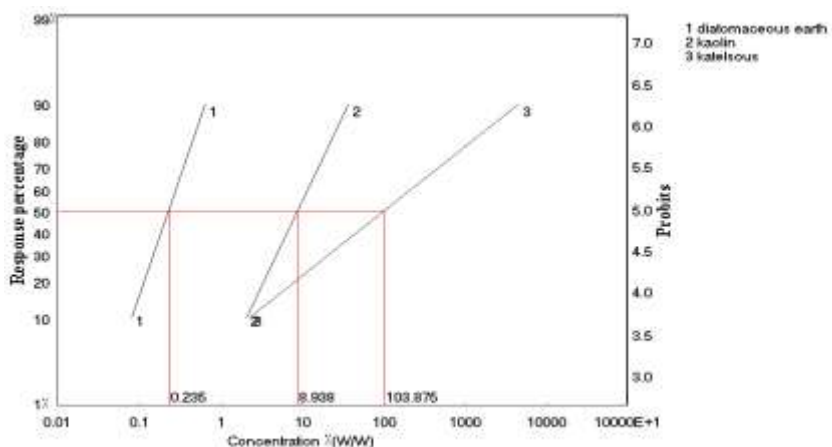


Fig. 3 : Probit regression lines for the toxicity of the tested inert dusts against adults of red flour beetle, *T. confusum* (H) after 24 hrs. exposure to treated wheat grains.

Golob (1997) reported that use of inert dusts particularly these based upon activated silica, increased as storage protectants in the grain industry. He added that kaolin have been used traditionally as grain protectant by small scale farmers in the developing world.

c. Katelsous :

Katelsous gave relatively lower mortalities at all tested rates after 24 hrs. for the three tested insects (Table 3). These results are in agreement with those of El-Lakwa *et. al.* (2001) who evaluated the efficiency of Katelsous (K.S), diatomaceous earth (D.E.) and their joint action against *S. oryzae*, *R. dominica* and *T. castanum*. They found that katelsous, when used alone, gave relatively lower mortality percentages of insect as compared with these resulting from the application of the mixture of diatomaceous earth and katelsous.

After three days of exposure, katelsous performed moderate protection particularly with the higher concentrations against the three tested insects. Higher rates (0.2 and 0.4% w/w) gave nearly complete mortality after 7 days of exposure for all insects (Table 3).

Mostafa and Al-Moagel (1989) reported that katelsous was more effective compared with permethrin and fenitrothion dusts against *Trogoderma granarium* beetle.

LC₅₀'s were 0.495, 0.496 and 103.875% w/w after one day of exposure when katelsous was used against *S. oryzae*, *R. dominica* and *T. confusum*, respectively (Tables 4,5 and 6, and Figs 1,2 and 3). This result showed that *T. confusum* was more tolerant than the two other insects. The present result coincided with those of Mostafa and Al-Moagel (1989) who found that all DE_s were less effective against *T. confusum*. El-Disouky (2002) studied the effectiveness of kaolinite and katelsous against *S. oryzae* at the concentration of 0.5 and 15% w/w, he reported that there were a significant differences in the mortality percentages after one and two weeks and katelsous was more effective than kaolinite.

On the bases of the above mentioned, results one may conclude that katelsous should be used at high concentration to achieve high percentage of mortality and to suppress the insect oviposition

II. Residual activity (Field experiment):

Further studies were conducted to evaluate the residual activity of the selected rates of 0.5, 8 and 0.4% w/w of DE, kaolin and katelsous, respectively. The results obtained from the field experiment were as follows:

a. Diatomaceous earth (D.E):

Data obtained in Table (7) indicate that DE mixed with wheat at rate of 0.5% w/w and stored for a period of six months suffered considerable decreasing in activity against *S. oryzae*, *R. dominica* and *T. confusum*

After one month of storage the mortality was 99.0, 95.4 and 89.3% for the three insects, respectively at the third day of exposure (Table 7), compared with 100 % mortality at the second day after exposure (Table 1). It was cleared that the degree of the effectiveness differed according to the storage period. After six months of storage the activity of DE considerably decreased, where the mortality % reached 47.5, 40.0 and 28.0% for the three insects, respectively, at the third day of exposure (Table 7).

Results obtained in Table (8) showed that there was more pronounced decreasing in activity with the longer periods of storage, where the loss of efficiency was increased from 1.0, 4.6 and 10.7% after one month to 52.5, 60.0 and 72.0% for the three tested insects, respectively 3 days of exposure after 6 months.

Table (7) : Residual activity of diatomaceous-earth at 0.5% w/w against the three tested insects after the indicated periods of storage.

Storage period (month)	%Mortality after the indicated exposure period (day)											
	1	3	5	7	1	3	5	7	1	3	5	7
	<i>S. oryzae</i>				<i>R. dominica</i>				<i>T. confusum</i>			
0	86.0	100	100	100	98.7	100	100	100	94.4	100	100	100
1	45.0	99.0	100	100	70.0	95.4	100	100	45.0	89.3	100	100
2	10.0	95.0	100	100	55.0	92.0	95.0	100	15.0	80.0	90.0	100
3	10.0	90.0	100	100	15.0	80.0	88.2	100	10.0	65.0	83.0	100
4	6.0	86.6	100	100	5.0	48.0	78.0	96.0	10.0	58.0	80.0	100
5	5.0	72.5	78.7	100	1.7	46.0	58.4	90.0	5.0	39.0	80.0	95.0
6	5.0	47.5	78.0	100	0.0	40.0	56.0	84.4	0.0	28.0	80.0	93.3

Table (8) : Reduction percentage in the efficiency of 0.5 % w/w diatomaceous-earth after different storage periods.

Treated insect	%Reduction in efficiency after different storage periods ^(a) (month)					
	1	2	3	4	5	6
<i>S. oryzae</i>	1.0	5.0	10.0	13.4	27.5	52.5
<i>R. dominica</i>	4.6	8.0	20.0	52.0	54.0	60.0
<i>T. confusum</i>	10.7	20.0	35.0	42.0	61.0	72.0

^(a)Reduction% in efficiency = 100 - % mortality at the third day of exposure after different storage periods.

b. Kaolin :

Data obtained in Table (9) indicate that kaolin mixed with wheat at rate of 8% w/w and stored for a period of 6 months suffered considerable decrease in the activity at the fifth day from exposure against the three tested insects throughout the storage periods.

Table (9) : Residual activity of kaolin at 8 % w/w against the three tested insects after the indicated periods of storage.

Storage period (month)	%Mortality after the indicated exposure period (day)											
	1	3	5	7	1	3	5	7	1	3	5	7
	<i>S. oryzae</i>				<i>R. dominica</i>				<i>T. confusum</i>			
0	63.3	91.7	100	100	63.3	92.2	100	100	44.4	96.5	100	100
1	6.7	51.7	65.5	96.7	5.0	35.0	77.5	90.8	10.0	31.7	47.5	72.5
2	5.0	21.7	38.3	63.7	1.7	18.3	50.0	82.5	5.0	5.0	25.0	40.0
3	3.3	15.7	20.0	36.7	1.7	10.0	17.5	77.5	1.7	5.0	20.0	35.0
4	0.0	10.0	16.7	20.0	1.3	5.0	13.3	51.0	0.0	1.7	17	22.5
5	0.0	5.0	13.0	15.0	0.0	3.5	7.1	40.0	0.0	1.7	15.0	20.0
6	0.0	2.3	10.0	6.7	0.0	1.7	5.0	15.0	0.0	1.7	15.0	15.0

The mortality percentages were 51.7, 21.7, 15.7, 10.0, 5.0 and 2.3% for *S. oryzae* while it were 35.0, 18.3, 10.0, 5.0, 3.5, 1.7% and 31.7, 5.0, 5.0, 1.7, 1.7, 1.7% for *R. dominica* and *T. confusum* after 1, 2, 3, 4, 5 and 6 months at the third day of exposure, respectively Table (9).

Data in Table (10) showed that the period of storage affected the efficiency of kaolin, where the loss of efficiency increased from 3.3, 9.2 and 27.5% after one month to 93.3, 85.0 and 85.0% after six months of storage, for the three tested insects, respectively.

Table (10): Reduction percentage in the efficiency of 8 % w/w kaolin after different storage periods.

Treated insect	%Reduction in efficiency after different storage periods ^(a) (month)					
	1	2	3	4	5	6
<i>S. oryzae</i>	3.3	36.3	63.3	80.0	85.0	93.3
<i>R. dominica</i>	9.2	17.5	22.5	49.0	60.0	85.0
<i>T. confusum</i>	27.5	60.0	65.0	77.5	80	85.0

^(a)Reduction % in efficiency = 100 – % mortality at the seventh day of exposure after different storage periods.

c. Katelsous :

Data obtained in Table (11) showed that the mortality percentages for *S. oryzae*, *R. dominica* and *T. confusum* at the first, third, fifth and seventh day of exposure, decreased with increasing the storage period of katelsous treated wheat for 6 months using the rate of 0.4% w/w where % mortalities were reduced from 100% to 13.0%, 100% to 35.0% and 100% to 22.0% during storage period from zero time to 6 months for the three tested insects, *S. oryzae*, *R. dominica* and *T. confusum*, respectively, at the 7th day of exposure.

Table (11) : Residual activity of katelsous at 0.4% (w/w) against the three tested insects after the indicated periods of storage.

Storage period (month)	%Mortality after the indicated exposure period (day)											
	<i>S. oryzae</i>				<i>R. dominica</i>				<i>T. confusum</i>			
	1	3	5	7	1	3	5	7	1	3	5	7
0	40.0	89.7	100	100	40	92.2	100	100	20.0	82.2	95.7	100
1	5.0	45.0	95.0	100	40.0	60.0	92.5	100	15.0	50.0	75.0	87.0
2	5.0	18.0	35.0	70.0	15.0	29.0	50.0	76.0	1.8	19.0	70.0	75.0
3	1.8	15.0	25.0	50.0	0.0	10.0	35.0	66.0	1.7	15.0	65.0	70.0
4	0.0	10.0	22.0	20.0	0.0	5.0	30.0	59.0	1.7	10.0	35.0	40.0
5	0.0	5.0	20.0	15.0	0.0	5.0	16.5	40.0	0.0	5.0	25.0	30.0
6	0.0	3.3	7.9	13.0	0.0	4.4	10.0	35.0	0.0	5.0	10.0	22.0

Data in Table (12) showed that there was a reduction in the efficiency with the increasing period of storage, where the decreasing in the efficiency were 87.0, 65.0 and 78.0% for the three tested insects, respectively 7 days of exposure after 6 months.

Table (12): Reduction percentage in the efficiency of 0.4 % w/w katelsous after different storage periods.

Treated insect	%Reduction in efficiency after different storage periods ^(a) (month)					
	1	2	3	4	5	6
<i>S. oryzae</i>	0.0	30.0	50.0	80.0	85.0	87.0
<i>R. dominica</i>	0.0	24.0	34.0	41.0	60.0	65.0
<i>T. confusum</i>	13.0	25.0	30.0	60.0	70.0	78.0

^(a)Reduction % in efficiency = 100 – % mortality at the seventh day of exposure after different storage periods.

The results of this study indicate that DE and katelsous can be used with success against *S. oryzae*, *R. dominica* and *T. confusum*, but their efficacies are influenced by several factors such as dose rates, exposure interval and storage period. The diatomaceous earth was highly activity followed by katelsous and kaolin against the three tested insects. Several published reports indicate satisfactory efficacy of DE for various insect pests in stored grain commodities (Arthur, 2002; Athanassiou *et al.*, 2003, Ferizli and Beris, 2005; Collins and Cook, 2006; Wakil *et al.*, 2010)

Activated kaolin clays (aluminum silicate) have been shown to be effective against a range of stored product beetle pests (Swamioppan *et al.*, 1976; Permual and patourel, 1990). The tested materials have low mammalian toxicity (Quarles, 1992) and can be applied directly to the grains (Korunic, 1998). Ebeling, (1971) reported that selected genetically by the action of these dusts, so that physiological resistance will not occur.

In conclusion, The obtained results showed that the diatomaceous earth was the most effective followed by katelsous and kaolin against the three tested insects. Also, the degree of effectiveness decreased with the increasing of storage period. *R. dominica* was more susceptible to DE, kaolin and katelsous than *S. oryzae* and *T. confusum*, while *T. confusum* was the most tolerant against the three tested materials. El-Sayed, *et al.*, (2010) found the same results. Finally, the present study suggests that the three inert dusts used may comply well with criteria of the proper protectants against stored grain insects where these agents materials have low mammalian toxicity and can be applied directly to the grain by using the same technology as that used for residual insecticides, in addition because the action of these materials is not dependent on metabolic pathways, it has been postulated that insects will not be selected genetically by the action of these dusts, so that physiological resistance will not occur.

REFERENCES

- Abbott, W.S. (1925). Method for computing the effectiveness of insecticides. J. Econ. Entomol, 18 (2): 265-273.
- 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., Kavlieratos, N.G., and Meletsis C.M. (2007). Insecticidal effect of three diatomaceous earth formulations, applied alone or in combination, against three stored-product beetle species on wheat and Maize. *Jour. of stored product research*, 43: 330-334.
- Athanassiou, C.G., Kavlieratos, N.G., Tsaganou, F.C., Vayias, B.J., Dimizas, C.B., and Buchelos, C.Th., (2003). Effect of grain type on the insecticidal efficacy of diatomaceous earth against *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae). *Crop Protection* 22, 1141-1147.
- Arnoud, L., Huong, T.T., Brostaux, Y., and Haubruge, E. (2005). Efficacy of diatomaceous earth formulations admixed with grain against populations of *Tribolium castaneum*. *Jour. of stored products research*, 41: 121-130.
- Arthur, F.H. (1996). Grain protectants :current status and prospects for the future. *Jour. of stored product research*, 32: 293-302.
- Badawy, A.I. and Naser Ibn Doraeham Y. (1991). Stored grain and products, pests and their control, King Soud Univ., Soudia Arabia (In Arabic).
- Baker, J.E. (1988). Development of four strains of *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae) on barley, corn (maize), rice and wheat. *Jour. of stored product research*, 24: 193-198.
- Champ, B.R.; and Dyte, C.E. (1976). Report of the FAO Global survey of pesticide susceptibility of stored grain pests. FAO, Rome.
- Collins, D.A., and Cook, A. (2006). Laboratory studies evaluating the efficacy of diatomaceous earths, on treated surfaces, against stored-product insect and mite pests. *Journal of Stored Products Research* 42, 51-60.
- Daglish, G.J., M. Eelkema and L.M. Harisson (1996). Control of *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae) in paddy rice using pirimiphos-methyl or fenitrothion in combination with several other protectants. *Jour. of stored products research*, 32: 247-253.
- Ebeling, W. (1971). Sorptive dusts for pest control. *Annual review of Entomology*, 16: 123-158.
- El-Disouky, M.I.M. (2002). Efficacy of insecticide formulations and alternative method against certain insects. Ph. D. Thesis, faculty of Agriculture, Alexandria University.
- El-Lakwah, F.A.; Mohamed, R.A. and El-Kashlan, I.H. (2001). Effectiveness of katelsous, diatomaceous earth and their action against three species of stored grain products insects. *Annals of Agric. Sc., Moshtohor*, 39 (1): 655-663.
- El- Nahal, A.K.M. ; El- Halfawy, M.A.; Abou Zieed, N.A. and Hassan, H. I. (1982). The relative susceptibility of certain Egyptian varieties of grains to infestation with *Sitophilus* weevils. *Agric. Res. Rev.*, 60(1): 41-52.
- El-Sayed, Ferial M. A.; El-Zun, H. M.; Abd El-latif, A. M. and Nasr, M.E.H (2010). Insecticidal effect of some inert dusts against three of stored grain insects at Kafr El-Sheikh Governorate. *Jour. of Plant Prot. and Pathology, Mansoura Univ.* , 1(12):959-972.
- Ferizli, A.G., and Beris, G., (2005). Mortality and F1 progeny of the lesser grain borer, *Rhyzopertha dominica* (F.) on wheat treated with diatomaceous earth: effects of rate, exposure period and relative humidity. *Pest Management Science* 61, 1103-1109.

- Golob P. (1997). Current status and future perspectives for inert dusts for control of stored product insects. *Jour. of stored products research*, 33: 69-79.
- IARC (International Agency for the Research of Cancer),(1997).Silica, some silicates, coal dust and para-aramid fibrils. IARC Working Group on the Evaluation of Carcinogenic Risks to Human, Lyon, France.
- Korunic, Z., (1998). Diatomaceous earths, a group of natural insecticides. *Journal of Stored Products Research*, 34: 87–97.
- Korunic, Z., (1999). Enhance diatomaceous earth an alternative to methyl bromide. *Australian Journal of Technology*, 2: 95-104.
- Mamadou, D., Bleu,G.D., Koffi,E.k., Dagobert,.K., Véronique,M.,and Mamadou,Da.(2014). Effectiveness of diatomaceous earth for control of *Sitophilus zeamais* (Coleoptera: Curculionidae), *Tribolium castaneum* and *Palorus subdepressus* (Coleoptera: Tenebrionidae). *Jour. of stored products research*, 57: 1-5.
- Mostafa, T.S. and Al-Moagel, N.H. (1989). Relative efficiency of certain natural inert dusts and synthetic chemical insecticides on *Trogoderma granarum*, (Everts.). *Annals of agric. Sci., Fac. Of Agric., Ain Shams Univ. Cairo, Egypt*, 34 (1): 381-400.
- Permul, D. and Patourel Le, G. (1990). Laboratory evaluation of acid-activated kaoline to protect stored paddy against infestation by stored product insects. *Jour. of stored products research*, 26: 139-153.
- Quarles, W., (1992). Diatomaceous earth for pest control. *The IPM Practitioner*, 14 (5/6): 1–11.
- Rees, D.P.(1996). Integrated management of insects in stored products. Marcel Dekker, New York, pp.1-29.
- Rigaux,M., Haubruge,E., and Fielah,P.G. (2001). Mechanisms for tolerance to diatomaceous earth between strains of *Tribolium castaneum*. *Entomologia experimentals et Applicata*, 101: 33-39.
- Subramanyam,B., and Hagstrum,D.W.(1995). Resistance measurment and management. In: Subramanyam, B., Hagstrum D.W. (Eds), *Integrated Management of Insects in Stored Products*. Marcel dekker Inc. New York pp. 331-398.
- Swamioppan M, Deivaval, C.S. and Jayaraj, S.(1976). Mode of action of activated kaolin on the pulse beetle *Callosobruchus chinensis*. *Madras Agricultural Journal* 63, pp.576-578.
- Ungsunantwiwat, A.and Mills, R.B., (1985). Influence of rearing medium on size and weight of adults of four *Sitophilus* (Cleoptera: Curculionidae) populations and on weight loss of host kernels. *Jour. of stored products research*, 21: 89-93.
- Wakil, W., Ashfaq, M., Ghazanfar, M.U., and Riasat, T., (2010). Susceptibility of stored product insects to enhanced diatomaceous earth. *Journal of Stored Products Research* 46, 248-249
- Waqas W, Tahira R. and Jeffrey C. L.(2013). Effects of combined thiamethoxam and diatomaceous earth on mortality and progeny production of four Pakistani populations of *Rhyzopertha dominica* (Coleoptera: Bostrichidae) on wheat, rice and maize. *Jour. of stored products research*, 52: 28-35.

التأثير الإباضي لبعض المساحيق الخاملة على ثلاث من حشرات المخازن بمحافظة المنوفية

فريال محمد علي السيد ، هشام مصطفى الظن ، عادل محمد عبد اللطيف ، سلوى مصطفى سيد أحمد و حسن بكري حسن حسين
قسم بحوث آفات المواد المخزونة - معهد بحوث وقاية النباتات - الدقي - مصر

اشتمل هذا البحث على دراسات معملية وحقلية لتقييم تأثير ثلاثة مساحيق خاملة وهي التربة الدياتومية والكاؤولين وقاتل سوس كمواد واقية لحبوب القمح من الإصابة بكل من سوسة الأرز وثاقبة الحبوب الصغرى وخنفساء الدقيق المتشابهة. تم خلط المساحيق مع حبوب القمح في المعمل بتركيزات مختلفة وتم تسجيل نسب الموت للحشرات وحساب التركيز القاتل لـ 50% (LC₅₀) والتركيز القاتل لـ 90% (LC₉₀) وميل خط السمية (Slope) والقدرة النسبية لهذه المساحيق. أظهرت النتائج المتحصل عليها من التجارب المعملية أن التركيز القاتل لـ 50% للتربة الدياتومية هو 0.234، 0.071، 0.235% وزن/وزن ضد سوسة الأرز وثاقبة الحبوب الصغرى وخنفساء الدقيق المتشابهة على التوالي بعد يوم واحد من المعاملة. كما أظهرت النتائج أن التركيز القاتل لـ 50% للكاؤولين وقاتل سوس كان 6.033، 6.306، 8.938% وزن/وزن و 0.495، 0.496، 103.88% وزن/وزن على التوالي بعد يوم واحد من تعريض الحشرات الثلاث المختبرة على التوالي. وأوضحت النتائج أن التربة الدياتومية كانت أكثر تأثيراً من المركبات الأخرى المختبرة حيث أدت إلى الموت الكامل للحشرات المختبرة بعد يومين من التعريض عند تركيز 0.5% وزن/وزن في حين أدى تأثير كل من الكاؤولين وقاتل سوس إلى الموت الكامل للحشرات المختبرة بعد أسبوع من التعريض عند تركيز 8، 0.4% وزن/وزن على التوالي. واستخدمت أعلى التركيزات تأثيراً على الحشرات المختبرة في الدراسة الحقلية (في مخازن المزارعين) وهي 0.5، 8، 0.04% وزن/وزن والتي تم الحصول عليها من التجارب المعملية لكل من التربة الدياتومية والكاؤولين وقاتل سوس على التوالي حيث خلطت بالقمح الذي تم تخزينه في مخازن المزارعين لمدة 6 شهور. كما أوضحت نتائج التجارب الحقلية في مخازن المزارعين أن الأثر الباقي للتربة الدياتومية بعد ستة شهور من التخزين وصل إلى نسبة موت 100%، 84.4%، 93.3% ضد الحشرات الثلاثة المختبرة على التوالي بعد 7 أيام من التعريض كما أظهرت النتائج أيضاً أن درجة الفعالية بهذه المركبات تتناقص مع زيادة فترات التخزين حيث أظهرت النتائج أن الكاؤولين عند تركيز 8% وزن/وزن أدى إلى نسبة موت تراوحت من 100% عند أول المعاملة (بدون تخزين) بعد 5 أيام من التعريض إلى 10.0%، 5.0%، 15.0% بعد 6 شهور من التخزين ضد الحشرات الثلاث المختبرة على التوالي. كما أن قاتل سوس عند معدل 0.4% وزن/وزن أدى إلى نسبة موت 100%، 100%، 95.7% ضد الحشرات الثلاث المختبرة على التوالي عند أول المعاملة (بدون تخزين) بعد 5 أيام من التعريض في حين وصل الأثر الباقي له بعد 6 شهور إلى موت 13.0%، 35.0%، 22.0% للحشرات الثلاثة المختبرة على التوالي.

وبصفة عامة فإن نتائج هذا البحث أظهرت أن التربة الدياتومية هي الأكثر فعالية ضد الحشرات المختبرة يليها قاتل سوس والكاؤولين. وأيضاً انخفضت درجة فعالية المواد المختبرة مع زيادة فترة التخزين.

قام بتحكيم البحث

كلية الزراعة - جامعة المنصورة
مركز البحوث الزراعيه

أ.د / على عبد الهادي
أ.د / محمود رمزي شريف

El-Sayed, Ferial M. A. et al.

1124 1125 1126 1127 1128 1129 1130 1131 1132

1133 1134 1135 1136 1137

1124 1125 1126 1127 1128 1129 1130 1131 1132

1133 1134 1135 1136 1137