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EFFICACY OF A NEW AMORPHOUS SILICA DUST, (DRYACIDE), AGAINST *Tribolium Confusum* DUV. (COLEOPTERA: CURCULIONIDAE) INFESTING STORED WHEAT GRAINS

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ABSTRACT

Amphorphous silica dust (Dryacide) was used to control adults of *Tribolium confusum* at concentrations of 200, 400, 800, and 1000 µ g silica dust / g wheat. Adult of tribolium confusum were placed in the three classes of wheat grains and incubated at 20 °C and 28 1 °C and 65 ± 5 % R.H. mortality counts were estimated after 48 and 168 hrs. Toxicity increased with concentration and temperature increase. Adults exposed to the dust for 7 days gave progeny in some treated replicates. Silica dust gave high percentages of mortality after long-term storage at the four periods (1, 8, 16 and 24 weeks) at 500 and 1000 µ g / g w. seed germination was not affected by treatment by silica dust.

INTRODUCTION

Wheat is considered one of the most important grains in the world as it has a very importa.t economic value since it is the main food for most humans. It has been noted that grain products are subject to infestation and loss by several organisms during growth, harvest, storage and consumption (Jilani and Saxena, 1990). Wheat production in Saudi Arabia has been increasing steadily (Aldyhim, 1990). It was found that insect infestation was the most important pest infesting wheat stored grains. *Tribolium confusum* Duv. was considered among the most economic coleopterous insect, which affects wheat production. Several methods of protecting stored grains from infestation have been used such as traditional chemical insecticides. Pollution and insect resistance were among the major problems, which resulted after using such chemicals (Redlinger *et al.*, 1988). The damage caused to the environment affected human health directly or indirectly. It was therefore very essential to find alternatives to chemical methods, such as using the new inert dust, silica dust, which has drawn the attention to control stored-grain pests in recent years.

The aim of the percent study was to access the toxicity of the new amorphous silica dust, (Dryacide) against *T. confusum* which infests three of wheat classes (durum hard and soft), to access its effect on percent progeny reduction, as well as to evaluate the effect of long-term storage of wheat on the toxicity of silica dust, and its effect on treated seed germination.

MATERIALS AND METHODS

The present study was conducted in the laboratory of Girls College of Education in Riyadh, scientific departments. Stock of sensitive *T. confusum*

was cultured in laboratory on wheat flour from infested wheat obtained from Plant Protection, College of Agriculture, King Saud University in Riyadh for three generations under controlled conditions of 28 1 °C and 65 ± 5 % R.H. The chemical composition of Dryacide sorptive (Dryacide Australia Pty, Ltd) used in this study was as follows : Colour white, Amorphous silica 92 %, Clay contaminants 4 %, Grit 4 %. It is a fine dust (95 % > 70 µm) with a bulk density of approx. 0.3 g / cm^3.

After the preliminary tests in laboratory, the following suitable concentrations were used: 200, 400, 600, 800 and 1000 µg / g whole wheat with four replicates for each treatment.

Tests of the toxicity of silica dust to *T. confusum* were conducted on three classes of wheat : hard, soft and durum. One hundred grams of each wheat class were placed in 72 clean 500 g jars, with each variety in 24 jars. Thus three groups of jars were obtained. The previously mentioned concentrations were added to the jars, with four replicates for each class, four jars for each class were left untreated and represented the control. Twenty newly emerged adult from *T.confusum* were placed in each jar. The method of Le Patourel and Singh (1984) was used silica dust with wheat grain. The jars were covered by muslin and tied with rubber bands. Jars were incubated under constant conditions of 20 °C ± 1 °C and 65 ± 5 % R.H. Another set of 72 jars were prepared as the previously mentioned method, but incubated under constant conditions of 28 °C ± 1 °C and 65 ± 5 % R.H. Mortality was assessed after 48 and 168 hrs. (2 and 7 days), dead insects were removed after each of the two periods. Mortality counts were corrected by the use of Abbott's formula (Abbott, 1925). The obtained results were used to draw the concentration and dosage mortality regression lines and to calculate the (LC_{50}) and (LC_{90}) values according to the method developed by Finney (1978).

To study the effect of silica dust on progeny reduction, adults from treated and untreated replicated in the last experiments were taken from jars on the 7th day of exposure. The jars were incubated at 28 °C ±1°C and 60 ± 1 % R.H. and were examined twice a week until no further progeny emerged.

$$\% \text{ progeny reductions} = \frac{(\text{No. progeny in control} - \text{No. progeny in treatment})}{\text{No. progeny in control}} \times 100$$

The effect of long-term storage treated with silica dust on its toxicity was tested after 1, 8, 16, and 24 weeks after treatment. Six plastic bags were prepared and filled with 25 kgs. Of wheat : hard, soft, and durum. Five hundred (500) and 1000 µg of silica dust were added to each bag of the three wheat classes. The previous bags were kept under lab. Temp. of 28 °C. similar six bags were prepared with the previous method, but kept under lab temperature of 20 °C ± 1 °C. forty eight (48) jars ½ kg were filled with 100 g of wheat for each from the previous concentrations with four replicates from each one. One jar was left from each concentration, representing the control. Twenty adults of *T.confusum* were added to each jar after a week and tied with muslin and rubber bands. Mortality was estimated after a week from

addition. As the previously mentioned investigation, other tests were assessed and mortality was estimated always after a week from addition of insects, after the other three periods of storage. Thus, the periods were 1, 8, 16, and 24 weeks as mentioned before.

For seed germination, 24 plastic dishes (13 × 18 cm) were prepared by placing 50 treated wheat grains and stored for 16 weeks in each dish on a thin layer (2 cm) of sterilized cotton and moistened with water. Grains from the three classes: hard, soft and durum were treated by 1000 µg / g silica dust with four replicates from each class (total = 12 dishes). Another 12 dishes with untreated grains were planted as before, representing the control. The same previous investigation was carried out but planted with stored grains for 24 weeks.

Data were statistically analyzed using Duncan (1951) method (analysis of variance, ANOVA).

RESULTS

The toxicities of silica dust to *T.confusum* are presented in Table (1). It was clearly observed that toxicity increased with the increase of concentrations after 48 hr of exposure in all of treatments of three wheat classes in an ascending order.

Toxicity increased also according to the two degrees of temperatures (20 °C and 28 °C) in most of treatments. It reached the maximum of all treatments at the highest concentration (1000 µg / g wh.) which was 45.5 % in (hard) under 28 °C. LC_{50} after 48 hr of exposure (Table 2) reached the minimum in (soft) wheat class (1865.03 µg / g wh.)under 20 °C. in (hard) LC_{50} was the minimum under 28 °C (1503.37 µg / g). Generally, LC_{50} and LC_{90} values decreased with the increase of temperature degrees except in the case of soft, where they increased.

Results showed that toxicity of *T. confusum* after 168 hr of exposure (Table 3) generally increased according to the increase in concentration of silica toxicity took a descending order according to the concentration decrease. Toxicity reached 86.25, 73.75 and 75.0 % at the highest concentration (1000 µg / g wh.) in hard, soft, and durum respectively under 28 °C, which was 55.0, 75.0 and 72.50 % in the previous three classes respectively at the highest concentrations. According to the LC_{50} values, it decreased with the increase in temperatures except in the case of hard, thus it increased (from 268.62 to 591.794) (Table 4).

Studies of the effect of silica dust on progeny of *T.confusum* (Table 5) showed that adults exposed to the dust for 7 days gave progeny in some treated replicates, but gave progeny in all untreated ones. Percent progeny reduction was 91.67 in durum at (800 µg / g), while was 87.5 in soft at (400 µg / g). No progeny appeared in hard of all treated replicates.

Results of the effect of long-term storage of wheat on toxicity of silica dust on *T. confusum* (Table 6) under the two degrees of temperatures (20 C and 28 C) showed that silica dust gave high percentages of mortality after the four periods of storage (1, 8, 16, 24 weeks). Minimum percentage of mortality

was 90 % after 1 week of storage under 20 °C (soft and hard) at 500 µg / g w. percentages of mortality reached 100 in extremely 50 % of the tested treatments. The remaining percentages fluctuated between the last two percentages of mortality (90.0 and 100 %).

Concerning the effect of long-term storage of wheat treated with silica dust on seed germination, it was found that storing treated seeds for 16 weeks did not decrease the percentage of germination compared with the control groups in all tested wheat varieties. Data are illustrated in (Figs. 5 & 6 and Tables 7 & 8). Differences between the three wheat varieties were highly significant after 16 and 24 weeks.

Table (1): Toxicity of silica dust to *T.confusum* Duv. After 48 hrs of exposure.

Concentration (µg / gw)	% Mortality						
	Wheat Classes	Hard		Soft		Durum	
	Temp. ± 1 °C	20°C	28°C	20°C	28°C	20°C	28°C
1000	-	12.50	45.00	26.25	25.00	25.00	27.50
800		11.25	36.25	25.00	20.00	18.75	25.00
600	-	8.75	21.25	17.50	18.75	12.50	17.50
400		3.75	15.00	16.25	15.00	10.00	13.75
200		3.75	10.00	11.25	11.25	3.75	13.75
Control	-	0	0	0	0	0	0

Table (2): Calculated slopes LC_{50}, LC_{90} values of silica dust after 48 hrs of exposure.

Category	Wheat classes	Temp. ± 1°C	Slope		LC_{50}		LC_{90}	
			20°C	28°C	20°C	28°C	20°C	28°C
Mortality of *T.confusum* after 48 hrs under 20 & 28°C	Hard		1.311	1.537	6534.28	1503.37	71212.34	10998.21
	Soft		1.531	1.498	1867.03	2182.54	14417.83	17653.87
	Durum		1.420	1.523	3319.57	1929.36	30122.84	15077.60

Table (3): Toxicity of silica dust to *T.confusum* Duv. After 168 hrs (7days) of exposure.

Concentration (µg / gw)	% Mortality						
	Wheat Classes	Hard		Soft		Durum	
	Temp. ± 1 °C	20°C	28°C	20°C	28°C	20°C	28°C
1000		86.25	55.00	73.75	75.00	75.00	72.50
800		83.75	51.25	73.75	76.25	73.75	72.50
600	-	75.20	42.50	68.75	75.00	70.00	73.75
400		66.25	41.25	56.25	75.00	51.25	70.00
200		42.50	40.00	53.75	71.25	22.50	70.00
Control	-	0	0	0	0	0	0

Table (4): Calculated slopes LC_{50}, LC_{90} values of silica dust after 168 hrs (7 days) of exposure.

Category	Wheat classes	Temp. ± 1 °C	Slope 20°C	Slope 28°C	LC_{50} 20°C	LC_{50} 28°C	LC_{90} 20°C	LC_{90} 28°C
Mortality of *T.confusum* after 168 hrs under 20 & 28°C	Hard	Durum	2.058	1.806	268.62	591.794	1229.965	3351.149
	Soft		1.992	2.085	325.80	252.858	1569.216	1136.081
			1.943	2.057	355.69	272.149	1780.915	1247.282

Table (5): Effect of silica dust on percent progeny reduction of *T.confusum* Duv. Adults exposed for 7 days under 28 ± 1 °C & 65 ± 5 % R.H.

Dosage (µg / gw)	% Progeny Reduction		
	Hard	Soft	Durum
200	-	-	-
400	-	87.5	-
600	0	-	-
800	-	-	91.67
1000	-	-	-
Mean No. Progeny in Control	0.25	2.0	3.0

Table (6): Effect of storage on toxicity of silica dust against *T.confusum* Duv.

Dosage (µg / gw)	%Mortality						
	Wheat Classes	Soft		Hard		Durum	
	Temp. ± 1°C	20°C	28°C	20°C	28°C	20°C	28°C
1 week							
500		90.0	91.25	90.0	91.25	92.50	91.25
1000		100.0	100.0	89.75	100.0	97.50	98.75
Control		5.0	0	5.0	0	8.75	0
8 weeks							
500		95.0	97.50	100.0	96.25	98.75	98.75
1000		100	98.75	100.0	98.75	98.75	100.0
Control		97.5	0	5.0	0	5.0	0
16 weeks							
500		97.50	100.0	100.0	100.0	98.75	100.0
1000		100.0	100.0	100.0	100.0	100.0	100.0
Control		10.0	5.0	5.0	5.0	10.0	10.0
24weeks							
500		98.75	100.0	100.0	100.0	98.75	100.0
1000		100.0	100.0	100.0	100.0	100.0	100.0
Control		10.0	6.25	15.0	3.75	10.0	10.0

Table (7) : ANOVA of the effect of silica dust on wheat seed germination after treatment with 1000 µg / gw, stored for 16 weeks.

Source	D.F.	Sum of squares	Mean squares	F Ratio	F Probability
Between groups	2	602.5833	301.2917	3.7600	0.0402
Within groups	21	1682.750	80.1310		
Total	23	2285.33			

Table (8) : ANOVA of the effect of silica dust on wheat seed germination after treatment with 1000 µg / gw, stored for 24 weeks.

Source	D.F.	Sum of squares	Mean squares	F Ratio	F Probability
Between groups	2	390.0833	195.0417	2.5316	0.1035
Within groups	21	1617.8750	77.0417		
Total	23	2007.9583			

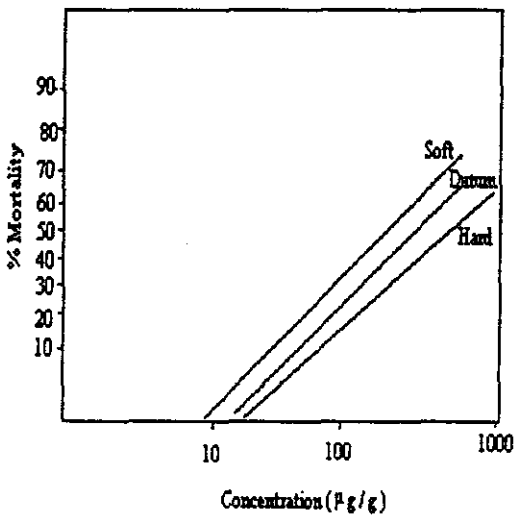

Figure (1): Ld-p mortality line for (Dryacide) against *T.confusum* Duv. under 20 C after 48 hrs.

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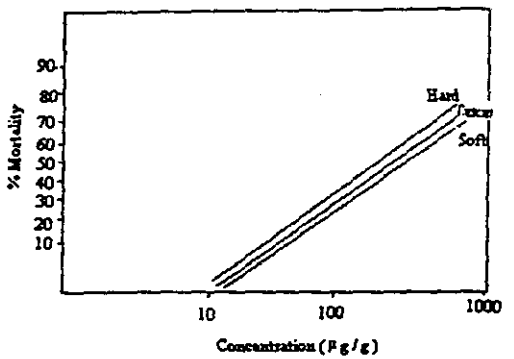

Figure (2): Ld-p mortality line for (Dryacide) against *T.confusum* Duv. under 28°C after 48 hrs.

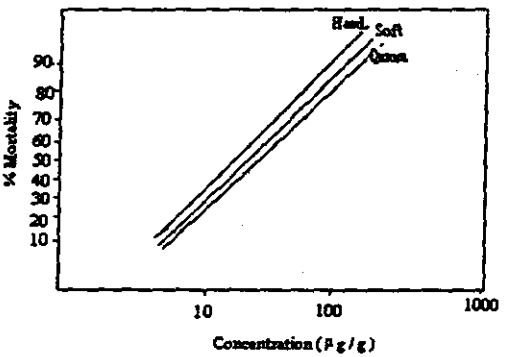

Figure (3): Ld-p mortality line for (Dryacide) against *T.confusum* Duv. under 20°C after 168 hrs.

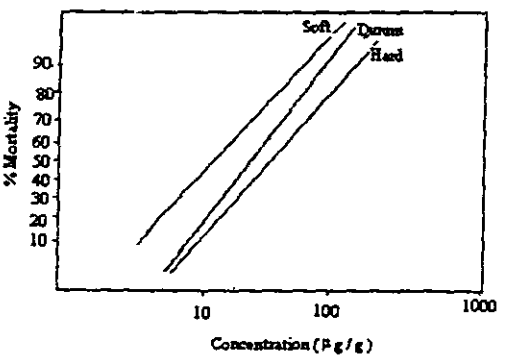

Figure (4): Ld-p mortality line for (Dryacide) against *T.confusum* Duv under 28°C after 158 hrs.

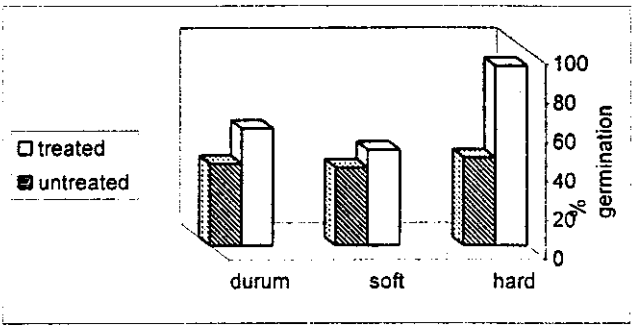

Fig. (5): Effect of silica dust on wheat seed germination after treatment with (1000 µg / g wheat), stored for 16 weeks under 28°C and 65 % R.H.

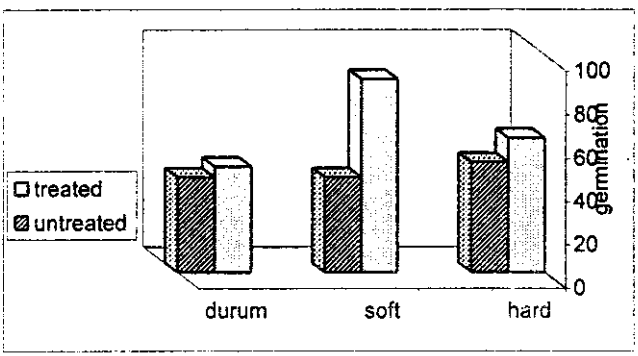

Fig. (6): Effect of silica dust on wheat seed germination after treatment with (1000 µg / g wheat), stored for 24 weeks under 28°C and 65 % R.H.

DISCUSSION

Wheat is considered one of the most important grains in the world, as it has a great economic value since it is the main food for most humans. It has been noted that grain products as well as other agricultural products are subject to loss and infestation during growth, harvest, preparation, storage and consumptions. Grains are subject to damage during storage due to several factors, mainly insect infection. Coleoptereus insects are considered the most important. Silica aerogels are efficient insecticides for controlling such insects, (Kamel, *et al.*, 1964; Gowers and Le Patourel, 1984; Le Patourel and Singh,1984; Desmarchelier and Dines 1987; Loschiavo, 1988; Aldryhim 1990).

Despite the fact that silica dusts are not generally toxic to mammals, but they simply move by air currents, causing respiratory dangers to mammals after long-term exposure (White and Loschiavo, 1989). New

amorphous silica dust "Dryacide" has safe advantages according to its heavy molecules. Silica dusts from the iner dusts with very small molecules able to absorb fats of insect epicuticle which prevents water evaporation, causing quick loss of insect water content and then death. it is clear from the present study that silica dust gave high percentages of mortality for *T.confusum* adults especially after a week of exposure. LC_{50} values showed that it reached 24.325 times in case of the variety "hard" at 20 °C for 48 hrs as after a week of exposure under the same temperature. It also reached 9.33 and 5.74 times in "durum" and "soft" under the same conditions respectively. Increase of temperature to 28 °C, also included high mortality, thus LC_{50} decreased sharply in "hard", "soft" and "durum", respectively under 28 °C of exposure. These results agreed with Kamel *et al.* (1984) in their experiments on silica aerogels SG-67 (Dri-Dri) and SG-68. they found that all of adult insects of stored grains: *R.dominica, T.castanium* and *O.surinamensis* were killed after 3 days with a dose of 0.1 % under summer conditions. Similar results were obtained by Desmarchelier and Dines (1987) on their experiments against four coleopterous species. They found that toxicity of "Dryacide" (diatomaceous earth coated with silica aerogels) has increased clearly after 28 days of exposure than after 7 days under 30 °C and 65 R.H. it reached 96 and 49 % respectively. The present results agreed also with Aldryhim(1990) results against *T.confusum* and *S.granaries* after using "Dryacide". He found that LC_{50} values have decreased by the increase of the exposure period from two seven days. Similar results were obtained with "Dryacide" against *R.dominica* by Aldryhim(1993).

The two periods of wheat exportation 2 and 7 days to "Dryacide" correlated positively with the increase of concentration in all treatments. Concerning the effect of the three types of wheat measuring by the LC_{50} values on mortality, it was found that there was no clear difference between the tested types except in two cases: first when *T. confusum* adults were exposed to 48 hrs. under 20 °C and second to 168 hrs. under 28 °C. thus the dust showed similar effect on soft, durum and hard. However, these results need further studies. White and Loschiavo (1989) mentioned that the type of food might have some effect on quantity of picked up treated diet with SG-67 by *O. mercator* fauvel beetle adults (the treated diet were bread pits, cereals and grind cereals. The frist reference of the effect of wheat types on toxicity of silica dust on *R. dominica* (F) was that of Aldryhim (1993). He mentioned that toxicity was higher in case of durum under low R.H. than in hard but lower than under high R.H. He added that the relations were not understood. The persent results showed that temperature had significant difference on mortality percentage of *T. confusum* at all treatments. Generally, it increased by the increase of temperature regardless the exposure period with little exceptions. This result might be explained by the fact that the raised insect activity according to higher temperatures might increase the rate of picking dust granules and then introducing higher mortality. In addition the high temperature might increase the efficiency of the dust itself. This opinion might agree with Kamel *et al.* (1964) in there tests against four beetles under summer conditions by using SG-67 & SG-68 at 0.04 & 0.1 % respectively that

gave complete mortality to adults after 3 days, but gave complete mortality under the same conditions at winter months.

The toxicity regression lines indicated obvious sensitivity of *T. confusum* and also showed that resistance for "Dryacide" could be excluded.

The obtained results showed clear persistence of the tested dust, which induced high mortality rates after 7 days exposure of the three wheat types. Then it was also indicated that this substance might offer fairly complete protection against beetle infestation. This phenomenon might be explained by the clear reduction on the percent progeny of adults, which might be attributed to the death of such adults before laying enough eggs and to the inability of the larvae to complete their life cycle. These present results agreed with Aldryhim (1990) against *S. granaries* by using silica dust. His experiments gave a significant reduction of progeny reached 100 % under 40 % R.H.

Concerning the present results about the effect of silica on vitality and seed germination, it was found that they were not affected after dust storage for 6 months. These results agreed with Kamel *et al.* (1964) and Aldryhim (1990).

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تأثير مسحوق سيليكا جديدة غير متبلورة (درارياسيد) علـــى خنفســاء الدقيــق المتشابهة *Tribolium confusum* Duv. التى تصيب حبوب القمح المخزونة.

البندرى فهد اليوسف – لمياء بنت أحمد الكريديس
كلية البنات بالرياض – المملكة العربية السعودية .

استعمل مسحوق السيليكا silica dust (dryacide) لمكافحة الحشرات البالغة لخنفساء الدقيــق المتشابهة.*Tribolium confusum* Duv وذلك بتركــيزات ٢٠٠ ، ٤٠٠ ، ٦٠٠ ، ٨٠٠ ، ١٠٠٠ µg /g من المسحوق على دقيق القمح التابع لثلاثة أصناف (classes) هى : hard ، soft ، durum ، . وقد وضعت الحشرات البالغة فى حضانين تحت درجتى حرارة ٢٠ ° ، ٢٨° ± ١ ° م ورطوبــة نسـبية ٦٥ ± ٥ % . وقد قدرت الحشرات الميتة بعد ٤٨ ، ١٦٨ ساعة . زادت النسـبة المئويـة للمــوت بزيــادة التركيز وكذلك بارتفاع درجة الحرارة . وقد أعطت الحشرات البالغة فى بعض المكررات المعاملـــة ذريــة ولكنها أعطت ذرية فى كل المكررات الغير معاملة (المجموعة الضابطة) وذلك بعد ٧ أيام .

أعطى مسحوق السيلكا نسبا مرتفعة من موت الحشرات فى القمح المعامل بعد فــترات التخزيــن الطويلة (١ ، ٨ ، ١٦ ، ٢٤ أسبوعا) فى التركيزين ٥٠٠ ، ١٠٠٠ w µg /g .

هذا ولم تؤثر المعاملة بمسحوق السيلكا على نسبة انبات حبوب القمح .