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USE OF SILICA AND BORIC ACID MIXTURE TO CONTROL THE KHAPRA BEETLE (*TROGODERMA GRANARIUM*, DERMESTIDAE: COLEOPTERA) ON STORED WHEAT SEEDS

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Abstract

This study was conducted effects mixture of powder (boric acid/silica) in concentrations (0.5, 10%) g/g and mixed with the seeds at a rate 20, 40 g / kg and at periods of exposure (1, 3, 6, 12, 16) weeks Respectively, among all stages of the *Trogoderma granarium* (eggs, larvae, pupa and adults) in addition to the to control treatment in which the individuals of this stage were left on the seeds without any treatment, the best results were in the adult stage when the concentration was 10% and the exposure period was 3 weeks, where it recorded 0.0 and 0.0 for the number of living individuals respectively, compared to the control treatment where the number of living individuals was 179.0 and 113.0, respectively, at the mixing ratios of powders with seeds 20 and 40 g / kg and the least effects were recorded in the results in the virgin stage, which recorded the number of live individuals at the exposure period of 16 weeks 1.66 and 0.0 individuals, respectively, compared to the control treatment, which reached the numbers of its living individuals to 452.66 and 431.33 individuals and at the mixing ratios of powders with seeds 20 and 40 g / kg, respectively and It was observed from the results there is a direct relationship between the effect ratios of the powders, the increase in the exposure period, the increase in the concentration and mixing ratios at all treatments except for the comparison treatment which the number of living individuals increased with the increase of time/week and for all stages of the *T. granarium* insect.

Key words: silica, boric acid, beetle, wheat seeds.

Introduction

Stored insects cause significant quantitative and qualitative economic damage to agricultural plants and their products and it has been indicated that 20% of crops are damaged by pests after the harvest, in third world countries, the percentage of losses is sometimes reached 80% (Al-Iraqi *et al*., 2008). Pesticides were used to protect crops and stored materials against harmful insects, which were accompanied by problems related to the negative effects of pesticides on humans, animals and their pollution to the environment, in addition to a decrease in their biological decomposition and targeting them to the desired natural enemies (Koul *et al*., 2008), in addition to the problems related to pesticide residues and pest resistance and that pesticides have killed nearly 200,000 people in the world and this is a big task for the World Health Organization (WHO) (Michael *et al*., 2009), despite the risks of pesticides, many countries still produce, store and use these chemical pesticides regularly, but in the European Union and the United States, many chemical pesticides were removed from the market. Because of the low restriction environmental and public health, all this made specialists need to search for modern and alternative methods of chemical pesticides to protect agricultural products, including the use of natural inert powders that can be added with grains as a mixture, therefore, the natural silicates have already been verified for their practical properties as pesticides (Athanassiou *et al*., 2006; Stathers *et al*., 2004), by adding inert powders to the surface of grains or as fogs and on the floor of the warehouse buildings to protect stored agricultural products from insects, in addition to the ability to remove powders from grains easily and non-toxic and provide protection for a long time and silica has proven to be an appropriate alternative to chemical insecticide treatments (Erb-Brinkmann, 2000), Many silica compounds contain high amounts of silicon dioxide (SiO_2). Most of them are crystalline forms and insects have not

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shown resistance inert powders, but in recent years silica has been made in a very different and smaller form from crystalline silicon oxide, to prevent toxic side effects of these products on mammals (Johnston *et al*., 2000; Merget *et al*., 2002). Therefore, inert powders can be an effective means to protect grains and stored products from stored insects, silica preparations, but newly developed formulations have been shown to be effective in humidity above 70% (Weishaupt *et al*., 2004), this research aims to evaluate the effectiveness of the powders of boric acid and silica mixture in mortality some stages of the hairy grain beetle *T. granarium* in concentrations (0, 5, 10%) and adding it to the grains with a mixing ratio of 20, 40 g/kg (mixture / seeds).

Materials and Methods

Insect rearing

The insect was raised in stored Insect Laboratory, to obtain adequate numbers of different stages of the *T. granarium* insect, by adding ten pairs of adult insects (female and male) / container and for several plastic containers measuring 15 × 25 cm to the wheat grain of IBA 99 and the grain was sterilized by leaving it in the freezer for 14 days at a temperature of -18 Celsius to get rid of the infection of the stored lesions, after which the grain containing the insects was transferred to in the incubator under the temperature of 38 ± 1 Celsius and a relative humidity of 55 ± 5%.

Prepare the mixture

The boric acid and silica mixture was prepared and at concentrations 0, 5, 10%, respectively g / g and mixed with into grains at a rate 20 and 40 g / kg (mixture / seeds) in addition to the control treatment that was left without any treatment to the wheat seeds.

Study the effect of silica and boric acid mixture on the stages of the Khapra insect.

Ten individuals were isolated from each stage of *T. granarium* (eggs, larvae, pupa and 10 adult pairs (male and female)) at the age of 2 days for each stages and separately in a cloth bag containing 250 g wheat seed of IPA 99 as duplicate and with three replicates for each treatment that was treated with concentrations and mixing ratios previously mentioned Separately, in addition to the control treatment and all of them were transferred to the incubator at a temperature of (38 ± 2)s and relative humidity (55 ± 5%), the increase and decrease rates for preparing insects for different roles are calculated after periods 1, 3, 6, 12, 16 weeks respectively, compared to the number of insects in the control treatment.

Statistical analysis

Use the complete random design and test the least significant difference at the 5% probability level to confirm the significance of the differences between the different treatments and use SAS, 2012. Statistical Analysis System, User's Guide, Statistical.

Results and Discussion

The results of table 1, showed the effect of the mixture of boric acid / silica powders and at concentrations 0, 5, 10%, respectively, in the egg stage when mixed with into grains at a rate of 20 and 40g/kg (mixture/seeds) when compared to the to control treatment in which the individuals of this stage were left on the seeds without any treatment at periods of exposure 1, 3, 6, 12, 16 weeks, respectively, the best effects were at the concentration of 10% and at the 16-week exposure period, where was recorded 0.0 living individuals compared to 338.66 individuals in the control treatment and the lowest results were at concentration 0.0% and the exposure period (1 week) and were recorded 24.0 live individuals. It was noted from the results there is a positive relationship between the ratios of influence, increase exposure period, increase concentration and mixing ratios, in all treatment except for the comparison treatment, in which the results are proven to increase the number of living individuals by increasing the time / week.

The results of the statistical analysis demonstrated the significance of the effect of increasing the exposure period, increasing concentration and the significance of the results of the overlap between them.

The results of table 2, showed the effect of the mixture of boric acid / silica powders and at concentrations 0, 5 and 10%, respectively, in the egg stage when mixed with to grains at 40 g / kg (mixture / seeds) compared to control treatment in which the individuals of this stage were left on the seeds without any treatment and at periods of 1, 3, 6, 12 and 16 weeks of exposure, respectively.

The best results were at the concentration of 10% and at the 12 week exposure period, where the number of living individuals was recorded 0.0 compared to 311.66 individuals in the control treatment and the lowest results were at the concentration of 0% and the exposure period 1 week recorded 20.0 live individuals and it was observed there is Positive relationship between Impact ratios and increasing the exposure period and on all treatment except for the comparison treatment and the results of the statistical analysis showed a significant effect of increasing the exposure period and concentration and prove Significance results of the overlap between them.

Table 1: Effect of boric acid / silica mixture on the *T. granarium* egg at mixing ratios of 20 g / kg wheat.

Boric acid / silica Conc.%	Exposure period / week					LSD value (P<0.05)
	1	3	6	12	16	
	Number of living individuals					
0	24.0	18.0	13.33	7.66	5.0	6.02 *
5	17.66	17	11.66	7.33	0	5.66 *
10	15	13.33	9.33	3.66	0	5.17 *
control	30	30	149.66	280.66	338.66	17.08 *
LSD value (P<0.05)	5.74 *	5.19*	9.63*	18.55*	22.02*	-
Overlap: 26;.05 *						

Table 2: Effect of boric acid / silica mixture on the *T. granarium* egg at mixing ratios of 40 g / kg wheat.

Boric acid / silica Conc.%	Exposure period / week					LSD value (P<0.05)
	1	3	6	12	16	
	Number of living individuals					
0	*20.0	17	13	4	3.33	6.31 *
5	14.33	11.66	9	2.66	0	5.44 *
10	13	13	5.33	0	0	5.09 *
control	30	30	161	311.66	340.66	17.35 *
LSD value (P<0.05)	5.01*	4.98*	11.91*	16.71*	19.00*	-
* 22.57 : Overlap						

Table 3: Effect of boric acid / silica mixture on the *T. granarium* pupa at mixing ratios of 20 g / kg wheat.

Boric acid / silica Conc.%	Exposure period / week					LSD value (P<0.05)
	1	3	6	12	16	
	Number of living individuals					
0	27.33	24.66	19	11.66	6.66	6.44 *
5	22.66	16.66	12.66	8.66	3.66	5.83 *
10	17.66	13.66	9.33	4	1.66	5.04 *
control	30	30	278.66	331.33	452.66	21.95 *
LSD value (P<0.05)	5.48*	5.20*	17.15*	19*	23.48*	-
* 23.59 : Overlap						

Table 4: Effect of boric acid / silica mixture on the *T. granarium* pupa at mixing ratios of 40 g / kg wheat.

Boric acid / silica Conc.%	Exposure period / week					LSD value (P<0.05)
	1	3	6	12	16	
	Number of living individuals					
0	25.66	20	19.33	8	0.0	5.61 *
5	18	14	11.33	2.66	0.0	5.46 *
10	15.33	11.66	9.33	0.0	0.0	4.78 *
control	30	145.66	236.66	403	431.33	19.83 *
LSD value (P<0.05)	5.65 *	12.95*	15.34*	18.07*	21.19*	-
* 23.59 : Overlap						

The results of table 3, showed the effect of the boric acid / silica powder mixture at concentrations 0, 5 and 10%, respectively, in pupae stage when mixed with to seeds at a ratio of 20 g / kg (mixture / seeds) compared to the control treatment in which the individuals of this stage were left on the seeds without any treatment and at periods of exposure 1, 3, 6, 12, 16 weeks, respectively, the best results were at the concentration of 10% and at the 16-week exposure period, where the number of living individuals was 1.66 compared to 452.66 individuals in the control treatment, the lowest results were at 0% and the exposure period is 1 week and registered 27.33 live individual and it was observed there positive relationship between Impact ratios by increasing the exposure period and on all transactions except for the comparison treatment. and the results of the statistical analysis showed a significant effect of increasing the exposure period and increasing the concentration and prove the significance of the results of the overlap between them.

The results of table 4, showed the effect of the mixture of boric acid / silica powders at concentrations 0, 5, 10%, respectively, in the pupae stage when they were mixed with seeds at 40 g / kg (mixture / seeds) compared to the control treatment in which the individuals of this stage were left on the seeds without any treatment and at periods of exposure 1, 3, 6, 12, 16 weeks and respectively, the best results were at 10% concentration and at the exposure time 12 weeks, when the number of living individuals was recorded 0.0 compared to 403.0 individuals in the control treatment and the lowest results were at the concentration 0% and the exposure period 1 week recorded 25.66 living individuals and observed positive relationship between the effects of increasing the exposure period and all treatments except for the comparison treatment. and the results of the statistical analysis proved significant effect of increased exposure period and increase concentration and the significance of the results of the overlap between them was proven.

The results of table 5, showed the effect of the mixture of boric acid / silica powders

Table 5: Effect of boric acid / silica mixture on the *T. granarium* larvae at mixing ratios of 20 g / kg wheat.

Boric acid / silica Conc.%	Exposure period / week					LSD value (P<0.05)
	1	3	6	12	16	
	Number of living individuals					
0	26.33	21.33	16.0	11.0	8.0	6.41 *
5	20.33	16.33	12.66	7.33	1.0	6.58 *
10	20.33	16.33	12.66	7.33	1.0	6.58 *
control	30	30	30.0	172.33	254.0	17.52 *
LSD value (P<0.05)	5.84 *	5.82*	5.02*	12.04*	15.60*	-
* 24.62 : Overlap						

Table 6: Effect of boric acid / silica mixture on the *T. granarium* larvae at mixing ratios of 40 g / kg wheat.

Boric acid / silica Conc.%	Exposure period / week					LSD value (P<0.05)
	1	3	6	12	16	
	Number of living individuals					
0	27.0	20.66	14.33	9	5.33	6.72 *
5	20.33	14.33	11.33	5.66	0.0	6.33 *
10	17.33	13.33	8.33	0.0	0.0	5.79 *
control	30	30	184.66	262.0	372	18.63 *
LSD value (P<0.05)	5.39*	5.69*	13.30*	15.55*	17.76*	-
* 19.84 : Overlap						

Table 7: Effect of boric acid / silica mixture on the *T. granarium* adult at mixing ratios of 20 g / kg wheat.

Boric acid / silica Conc.%	Exposure period / week					LSD value (P<0.05)
	1	3	6	12	16	
	Number of living individuals					
0	33.66	3	0.0	0.0	0.0	6.57 *
5	19.33	2	0.0	0.0	0.0	4.96 *
10	8	0.0	0.0	0.0	0.0	5.77 *
control	60	179	192	371.33	398	15.47 *
LSD value (P<0.05)	6.89*	9.64*	9.55*	12.97*	16.34*	-
* 22.74 : Overlap						

Table 8: Effect of boric acid / silica mixture on the *T. granarium* adult at mixing ratios of 40 g / kg wheat.

Boric acid / silica Conc.%	Exposure period / week					LSD value (P<0.05)
	1	3	6	12	16	
	Number of living individuals					
0	33.66	0.0	0.0	0.0	0.0	6.51 *
5	30	0.0	0.0	0.0	0.0	5.66 *
10	21.66	0.0	0.0	0.0	0.0	5.08 *
control	60	113.0	208.33	384.66	409.66	16.43 *
LSD value (P<0.05)	6.80*	8.39 *	10.32*	15.33*	19.50*	-
* 24.69 : Overlap						

and at concentrations 0, 5, 10%, respectively, in *T. granarium* larvae when mixed with into seeds by 20 g / kg (mixture / seeds) compared to the control treatment in which the individuals of this stage were left on the seeds without any treatment and at periods of exposure 1, 3, 6, 12 and 16 weeks of exposure periods 1, 3, 6, 12, 16 weeks and respectively, the best results were at the concentration of 10% and at the exposure period of 16 weeks where 0.0 was recorded for the number of living individuals compared to 254.0 individuals in the control treatment and the lowest results were at the concentration 0% and the exposure period was 1 week and recorded 26.33 live individuals and it is observed that there is Positive relationship between impact ratios and increase the exposure period and all treatments except for the comparison treatment and the results of the statistical analysis showed a significant effect of increasing the exposure period and concentration and prove the significance of the results of the overlap between them.

The results of table 6, showed the effect of the mixture of boric acid / silica powders and at concentrations 0, 5, 10%, respectively, in *T. granarium* larvae when mixed with into seeds by 20 g / kg (mixture / seeds) compared to the control treatment in which the individuals of this stage were left on the seeds without any treatment and at periods of exposure 1, 3, 6, 12 and 16 weeks respectively, the best results were at the concentration of 10% and at the exposure period of 12 weeks where the number of living individuals 0.0 was recorded compared to 262.0 individuals in the control treatment and the lowest results were at the concentration 0 % and the exposure period was 1 week and recorded 27.00 live individuals and it is observed that there is Positive relationship between impact ratios and increase the exposure period and all treatments except for the comparison treatment and the results of the statistical analysis showed a significant effect of increasing the exposure period and concentration and prove the significance of the results of the overlap between them.

The results of table 7, showed the effect of the mixture of boric acid / silica powders

and at concentrations 0, 5, 10%, respectively, in *T. granarium* larvae when mixed with into seeds by 20 g / kg (mixture / seeds) compared to the control treatment in which the individuals of this stage were left on the seeds without any treatment and at periods of exposure 1, 3, 6, 12 and 16 weeks respectively, the best results were at the concentration of 10% and at the exposure period of 3 weeks where the number of living individuals 0.0 was recorded compared to 179.0 individuals in the control treatment and the lowest results were at the concentration 0 % and the exposure period was 1 week and recorded 33.66 live individuals and it is observed that there is Positive relationship between impact ratios and increase the exposure period and all treatments except for the comparison treatment. and the results of the statistical analysis showed a significant effect of increasing the exposure period and concentration and prove the significance of the results of the overlap between them.

The results of table 8, showed the effect of the mixture of boric acid / silica powders and at concentrations 0, 5, 10%, respectively, in *T. granarium* larvae when mixed with into seeds by 20 g / kg (mixture / seeds) compared to the control treatment in which the individuals of this stage were left on the seeds without any treatment and at periods of exposure 1, 3, 6, 12 and 16 weeks respectively, the best results were at the concentration of 10% and at the exposure period of 3 weeks where the number of living individuals 0.0 was recorded compared to 113.0 individuals in the control treatment and the lowest results were at the concentration 0 % and the exposure period was 1 week and recorded 33.66 live individuals and it is observed that there is Positive relationship between impact ratios and increase the exposure period and all treatments except for the comparison treatment and the results of the statistical analysis showed a significant effect of increasing the exposure period and concentration and prove the significance of the results of the overlap between them.

It also appeared from the results all tables that the adult stage is the most sensitive for all previous treatments, and the results showed that the larvae come second in its sensitivity, followed by eggs stage and then pupae in the last sequence also, it was observed from the results of the experiment the stability of the treated powders to the bottom of the treated seed layer away from the location of the stored insects on the surface of the grains and this agreed with what (Porca *et al*., 2003). As he mentioned that adding silica powder to the grain pile has reduced many insects that are present on the surface of grains, such as *T. granarium* and he pointed out that it is one of the important physical techniques in protecting against the insects of stored materials that are used when entering the grain for warehouses. (Subramanyam and Roesli, 2000) indicated that the treatment of the upper or lower parts of the grain stacks with inert powder without mixing them is one of the practical techniques for protecting the grain from the effects of stored insects and at the same time reducing the amount of powder used as it is possible to use the inert powder by adding it as a thick layer over the stacks of grains or stored products without mixing them with them to protect them from the insects of the stored materials and the results of the study agreed with what (Ulrichs *et al*., 2006a) record that small-volume preparations have a greater ability to absorb fats from external cuticle of the insect and thus increase the rate of insect mortality, according to the method of using silica because it is used as an contact insecticide and it must reach the pests stored crops, as for (Ulrichs *et al*., 2006b) demonstrated that silica can be successfully used for pest management if applied well and when studying the different and effective applied methods and through biological tests, the effectiveness of the various applied silica products was checked in the different development stages of the mustard leaf beetle *Phaedon cochlearia* Fab and cabbage worm for the large white butterfly *Pieris brassicae* L. (al-Iraqi and Ma'an, 2007; Wang *et al*., 2009) studied adding inert powders on the surface of stored grain to prevent an insect infection. *Trogoderma granarium* and prove the efficacy of natural and industrial inert powders to control larvae and adult stages, for exposure periods 4 and 6 days and that the adults were most sensitive to the inert substance by twice compared to the third-age larvae, scratching it to the surface layer of cuticle and removing the thin waxy layer, causing increased water loss from the insect's body, it causes dehydration and then death, or absorbs the surface fat of the cuticle which increases the water loss during the cuticle. the results of the study are also compatible with (Athanassiou *et al*., 2006) existence a positive correlation between dose and mortality has been established by many authors in stored product protection and the differences in the influence of the different stages of the insect due to the differences in the morphological structure and physiology of the insect. In addition, skin thickness during insect development can play a vital role because the initial insect stages contain thinner skin and were killed more quickly in experiments. These results were also supported by Mucha-Pelzer *et al*., (2008)

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