Science Arena Publications
Specialty Journal of Biological Sciences
Available online at www.sciarena.com
2015, Vol, 1 (2): 7-13

Entomotoxicity assay of Nanoparticle 4-(silica gel Cab-O-Sil-750, silica gel Cab-O-Sil-500) Against Sitophilusoryzae Under Laboratory and Store Conditions in Egypt

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ABSTRACT: Silica gel Cab-O-Sil-750, silica gel Cab-O-Sil-500 silica gel Cab-O-Sil-750, silica gel Cab-O-Sil-500 were tested against the rice weevil Sitophilus oryzaeunder laboratory and store conditions. Results showed that under laboratory conditions, the number of mortality of S. oryzaewere significantly increased to 49.4±4.4, 57.8±5.3 and 50.6±3.2 individuals after treated with 3% of silica gel Cab-O-Sil-750 , silica gel Cab-O-Sil-500 after 7, 21and 45 days, as compared to 1.0 ± 2.8, 1.0 ± 5.1 and 2.0 ± 3.1, respectively in the control.The number of mortality scored a higher mortality reached to 37.1±3.2, 40.4±3.4 and 44.7±5.1 individuals after treated with1% of Silica gel Cab-O-Sil-750, silica gel Cab-O-Sil-500 nanoparticles as compared to 2.0 ±3.8, 1.0 ±5.1 and 2.0 ±3.1 individuals, respectively.The effect of the nanoparticles (Silica gel Cab-O-Sil-750, silica gel Cab-O-Sil-500) against Sitophilus oryzae under store conditions. In 0.2% treatments with nano Silica gel Cab-O-Sil-750, silica gel Cab-O-Sil-500, and the number mortality of S. oryzae were significantly increased to 14.1±2.3, 28.2±8.8 and 29.8±3.9 individuals after nano Silica gel Cab-O-Sil-750, and silica gel Cab-O-Sil-500 treatments as compared individuals in the controlThe number of eggs laid /female were significantly reduced. After 100 and 120 days the number of eggs laid/ female were significantly decreased to 6±1.0 and 11±0.51 as compared to 99.1±1.43 and 97.2±1.82 in the control. The % reduction values in the number of laid eggs and adult emergence after 120 days were 91 and 90%, respectively in case of Silica gel Cab-O-Sil-750 , silica gel Cab-O-Sil-500 application on foam covering gunny bags provided promising oviposition deterrence, toxicity and suppressing S. oryzae infestation, persistence and protecting rice seeds from beetles' infestation for 120 days during storage.
Key words: Sitophilusoryzae, silica gel Cab-O-Sil-750, silica gel Cab-O-Sil-500, nanoparticles

Introduction

Insect pests cause extensive damage to stored grains, both qualitatively and quantitatively (Hall, 1970; Semple et al., 1992).Many grain storage managers use synthetic insecticides to reduce losses of stored grain to insect pests. Nanoparticles can be arranged or assembled into ordered layers, or mine layers (Ulrich et al., 2006).

Nanotechnology, a promising field of research opens up in the present decade a wide array of opportunities in the present decade and is expected to give major impulses to technical innovations in a variety of industrial sectors in the future. The potential uses and benefits of nanotechnology are enormous. These include agricultural productivity enhancement involving nanoporous zeolites for slow release and efficient dosage of water and fertilizer, nanocapsules for herbicide delivery and vector and pest management and nanosensors for pest detection. The atom by atom arrangement allows the manipulation of nanoparticles thus influencing their size, shape and orientation for reaction with the targeted tissues. It is now known that many insects possess ferromagnetic materials in the head, thorax and abdomen, which act as geomagnetic sensors. In this paper, our discussion is focused on nanoparticles in insects and their potential for use in insect pest management. (Bhattacharyya et al., 2010). They reported that the potential uses and benefits of nanotechnology are enormous. These include agricultural productivity enhancement involving nanoporous zeolites for slow release and efficient dosage of water and fertilizer, nanocapsules for herbicide delivery and vector and pest management and nanosensors for pest detection. Thus nanotechnology will revolutionize agriculture including pest management in the near future. Over the next two decades, the Green Revolution would be accelerated by means of nanotechnology.Debnathet al. (2010) reported that thediatomaceous earth was used to design amorphous nano sizedhydrophilic, hydrophobic, and lipophilic, surfacefunctionalizedsilica nanoparticle (SNP) was tested againstrice weevil S. oryzae and its efficacy was compared with bulksizedsilica, application of hydrophilic SNP at 1 g kg -1 couldkill more than 80% of the insects, after 7 days of exposure, 95and 86% mortality were obtained with hydrophilic andhydrophobic SNPs at 1 g kg -1, respectively. Insect mortality due to silica nanoparticles treatment wasobtained at dose rates almost comparable with those ofcommercially available DE formulations ranging from 500 to5000 mg kg-1 (Subramanyam and Roesli, 2000; Vardemanetal., 2007).

Nanoparticles of oxides like SiO2 produced and characterized in our laboratory were tested against insect pests and pathogens. Nanosilica against insect pests shows nearly 100% mortality (Debnath et al. (2010).(Arthur, 1996). However, there are several reasons to search for alternatives to synthetic insecticides: consumer preference for food without insecticide residues, worker safety concerns, resistant insect populations, and deregistration of current synthetic insecticides. Higher plants are a good source of novel insecticides (Prakash & Rao, 1997).Rice is the most important food crop for more than half of the world's population. Losses in rice storage due to insect pests affect food availability for a large number of people. Milled rice is attacked by various insect pests during storage (Cogburn, 1980). Storage and upkeep of agricultural products are very important post harvest activities. Considerable amount of rice grains is being spoiled after harvest due to chemical insecticides compounds (Larsson et al., 1992). Nano Al2O3 and amorphous nano SiO2 were found to be highly effective and nanoSilica gel Cab-O-Sil-750, silica gel Cab-O-Sil-500 was moderately effective against S. oryzae. But nano Al_2O_3 has deleterious effects on seeds, whereas non crystalline nano SiO2 has no such adverse effect on rice seeds. Here we present the first report showing that nanocides, especially nano SiO2 can be effectively used to control insect pests (Leiderer and Dekorsy, 2008).

The rice weevil, S. oryzae (L) .(Coleoptera: Curculionidae) is a major pest of stored rice in Egypt, and has been spread worldwide by commerce. Both the adults and larvae feed on whole grains. They attack wheat, corn, oats, rye, barley, sorghum, dried beans and cereal. It causes extensive losses in the quality and quantity of commercial products as well as deterioration of seed viability worldwide (Madrid et al., 1990 andOwoladeet al. (2008). Currently, chemical control is the most commonly used strategy against the pests. There are many chemicals that are toxic to stored-grain pests, including insecticides such as organophosphates, pyrethroids and fumigants such as methyl bromide and phosphine (Park et al., 2003; Kljajic and Peric, 2006 and Wadhwa 2009). These chemicals are effective for pest control but have several problems to users (Okonkwo and Okoye, 1996). Nano-pesticides and nano-encapsulated pesticides are expected to reduce the volume of application and slow down the fast release kinetics. (Edibolet al. 2003, Niemeyer and Doz 2001, Leiderer and Dekorsy, 2008). Mode of action occur destruction of the natural water barrier, the waxy layer of the cuticle, results in the desiccation of arthropods, Desiccation follows Fick's law of diffusion., Water absorption by silica particles is not important, Since there is no chemical alteration of the absorbed lipids we can describe the modeof action as physisorption(Leiderer and Dekorsy, 2008). Targeted nanoparticles often exhibit novel characteristics like extra ordinary strength, more chemical reactivity and possess a high electrical conductivity. Thus, nano-technology has become one of the most promising new technologies in the recent decade. Nanoparticles possess distinct physical, biological and chemical properties associated with their atomic strength (Leiderer and Dekorsy, 2008). Nanoparticles (which are 1-100 nm in diameter) are agglomerated atom by atom, and their size (and some-times shape) may be maintained by specific experimental procedure (Roy, 2009). Nanoparticles can be arranged or assembled into ordered layers, or mine layers (Ulrich et al., 2006). Such self-assembly is due to forces such as hydrogen bonding, dipolar forces, hydrophobic interactions, surface tension, gravity and other forces.

Thus nanotechnology deals with the targeted nanoparticles as and when the particles exhibitdifferent physical strength, chemical reactivity, electrical conductance and magnetic properties (Nykypanchuk et al., 2008). Nanotechnology, a promising field of research opens up in the present decade a wide array of opportunities and is expected to give major impulses to technical innovations in a variety of industrial sectors in the future. Nanoencapsulation is currently the most promising technology for protection of host plants against insect pests. Thus nanotechnology will revolutionize agriculture including pest management in the near future. Over the next two decades, the green revolution would be accelerated by means of nanotechnology (Bhattacharyya et al., 2010).

Materials And Methods

Insects rearing

S. oryzae was collected from infested rice obtained from a local market and reared in glass jars under laboratory conditions of 30°C ± 1°C, 75 ± 5% relative humidity (RH) in continuous darkness. The RH was maintained by using saturated solution of sodium chloride (Winston and Bates1960). After the pupal stage the adults less than 24 hrs old were used for the experiments.

Silica gel Cab-O-Sil-750, silica gel Cab-O-Sil-500 silica gel Cab-O-Sil-750, silica gel Cab-O-Sil-500Zinc Oxide Nanorods The silica gel Cab-O-Sil-750, silica gel Cab-O-Sil-500nanorods are prepared using the method described (Zhang, et al 2007). The process involves the ultrasonic irradiation of 50 mL of aqueous solution containing 0.05 M of zinc acetate and 0.05 M of triethanolamine, at 80°C for two hours. The resulting product was washed several times with de-ionized water followed by methanol. Filtered and dried at °۲۰۰C in air for 2 hours. The structural morphology of the particle was done by scanning electron microscope and presented in Fig. (1and 2). The particles are found to be rod shaped with 100 to 250 nm dia and 1 to 2 nm length

Repellency test

The experiments were conducted in an arena in choice test. Disc of filter paper (Whatman No. 1) was treated with the tested nanoparticles silica gel Cab-O-Sil-750, silica gel Cab-O-Sil-500at 1 %conc. and placed in cell A. While filter paper treated with distilled water and emulsifier only as control was placed in the cellB. Twenty newly emerged beetles were introduced into each arena. After 1, 2, 3,4,5,6 and 7 days, the number of beetles present in the cells A and B was recorded. The percentages of repellency values were calculated using the equation: D= (1- T/c) x 100 (Lwandeet al . ,1985) where T and C represent the mean number of beetles in cells A and B (Treated and untreated) , respectively .

The insecticidal activity of tested nanoparticles

Experiment was designed to test the initial as well as the persistent effect of the tested nanoparticles silica gel Cab-O-Sil-750 , silica gel Cab-O-Sil-500on beetles as cumulative mortality during successive intervals (0, 2, 4, and 7 days). Foam granules about 1cm in diameter were treated at time (zero time) with tested nanoparticles , dried and provided with heat sterilized rice seeds (100g/each) fastened each with a string. Then all treatments were used immediately as non-choice test. The foam granules treated with the tested nanoparticles were mixed with rice seeds (2g foam/100g seeds) according to Abd El-Aziz (2001).

Ovipostional deterrent effect of tested nanoparticles(no choice test)

To evaluate the oviposition deterrent of the tested nanoparticles silica gel Cab-O-Sil-750, silica gel Cab-O-Sil-500, a pair of newly emerged beetles,was placed with treated or untreated broad seeds in glass jars (250 cc capacity) covered with muslin. The beetles were left to lay eggs, and then the deposited eggs were counted on the seeds in the treated and untreated jars. Each experiment was repeated five times, (Abd El-Aziz and Ismail, 2000). The number of deposited eggs was used as a criterion for the evaluation of reduction percentages.

Reduction % = [100 – No. of deposited eggs in treatment] X 100

No. of deposited eggs in control

The percent reduction is an index of effectiveness of the appliednanoparticles in reducing infestation and was calculated according to, Su (1989).

The persistence of nanoparticles during storage

Experiment was designed to test the persistent effect of silica gel Cab-O-Sil-750 , silica gel Cab-O-Sil-500 on foam as surface protectant at 20 day intervals over 120 days. All gunny sacks (20x20 cm each) were full ofheat sterilized rice seeds (100 g each), fastened, each with a string. The foam granules (about 1 cm in diameter) were sprayed with treatments, dried and provided as a layer between sacks. Following exposing to those treatments, two pairs of newly emerged beetles (2–3 day) were placed in a jar (2 l capacity with four gunny sacks) and observed for egg laying. The laid eggs were counted on the seeds in the treated and untreated jars. Each experiment was repeated five times, (Abd El-Aziz 2001).

The number of deposited eggs was used as a criterion for the evaluation of reduction percentages.

Reduction % = (100-no of laid eggs in treatments) X 100

No of laid eggs in control

The percent reduction is an index of effectiveness of the applied nanoparticles in reducing the pest infestation and was calculated according to Su (1989) .Dead beetles were removed and the jars were kept

under the same experimental conditions until the emergence of F1 progeny adults occurred. Percentage reduction in adult emergence or inhibition rate (% IR) was calculated as:
%IR = (Cn _ Tn) 100/Cn
Where: Cn is the number of newly emerged insects in the untreated (control) jar
TN is the number of insects in the treated jar (Tapondjouet al. 2002).

Results

Data in table 1 show that under laboratory conditions, the number of mortality of S. oryzaewere significantly increased to 49.4±4.4, 57.8±5.3 and 50.6±3.2 individuals after treated with 3% of silica gel Cab-O-Sil-750 , silica gel Cab-O-Sil-500 after 7, 21and 45 days, as compared to 1.0 ± 2.8, 1.0 ± 5.1 and 2.0 ± 3.1, respectively in the control. When S. oryzae were treated with Silica gel Cab-O-Sil-750, silica gel Cab-O-Sil-500 under laboratory conditions, the number of mortality scored a higher mortality reached to 37.1±3.2, 40.4±3.4 and 44.7±5.1 individuals after treated with1% of Silica gel Cab-O-Sil-750, silica gel Cab-O-Sil-500 nanoparticles as compared to 2.0 ±3.8, 1.0 ±5.1 and 2.0 ±3.1 individuals, respectively (Table 1).

The effect of the nanoparticles (Silica gel Cab-O-Sil-750, silica gel Cab-O-Sil-500) against Sitophilus oryzae under store conditions showed in Table 3. In 0.2% treatments with nano Silica gel Cab-O-Sil-750, silica gel Cab-O-Sil-500, and the number mortality of S. oryzae were significantly increased to 14.1±2.3, 28.2±8.8 and 29.8±3.9 individuals after nano Silica gel Cab-O-Sil-750, and silica gel Cab-O-Sil-500 treatments as compared individuals in the control (Table 2). At higher concentrations of 3% the mortality percent were significantly increased to 89.0±1.1 individuals after 45 days of applications as compared to 3.0±2.6 individuals in the control, (Table 2).

Data in Table (3) indicated that accumulative mortality (%) of S. oryzae beetles increased gradually by increasing the period of exposure in case of treated foam with different tested nanoparticles Silica gel Cab-O-Sil-750 , silica gel Cab-O-Sil-500. Silica gel Cab-O-Sil-750, silica gel Cab-O-Sil-500 had the highest cumulative mortality (69.7%) after seven days as compared to (1.1 %) after seven days in the control Table 3. In this respect, Chander and Ahmed (1986) applied different doses of the essential oil of Acoruscalamusto seeds of green gram Vignaradiata (Wilcz) to protect them against Callosobruchuschinensis and found that 1ml/Kg offered a high degree of protection up to a period of 135 days. Prolonged protection of the seeds was mainly due to a high adult mortality besides reduced oviposition and low hatching. Foam sprayed with clove oil (5%) and placed between sacks caused the highest mortality (66.6%) of C. maculatus as compared with treated sacks or foam inside sacks (63.3% and 42%, respectively) after 6 days of storage (Abd El-Aziz, 2001) .The same results were obtained by Chander and Ahmed (1986); Saxenaet al., (1976), Surabaya et al., (1994) and Sabbour (2012).

The persistence of nanoparticles tested during storage

The persistent effect of nanoparticles with on foam covering gunny bags displayed several different modes of action by reducing oviposition and adult emergence (F1) of Sitophilus oryzae (Table 4). The oviposition was completely inhibited when stored rice seeds were treated with Silica gel Cab-O-Sil-750, silica gel Cab-O-Sil-500 during 20, 40, 60 and 80 days of storage. The number of eggs laid /female were significantly reduced. After 100 and 120 days the number of eggs laid/ female were significantly decreased to 6±1.0 and 11±0.51 as compared to 99.1±1.43 and 97.2±1.82 in the control Table 4. The % reduction values in the number of laid eggs and adult emergence after 120 days were 91 and 90%, respectively in case of Silica gel Cab-O-Sil-750 , silica gel Cab-O-Sil-500 application on foam covering gunny bags provided promising oviposition deterrence, toxicity and suppressing S. oryzae infestation, persistence and protecting rice seeds from beetles' infestation for 120 days during storage.

Abd El-Aziz and Sharaby (1997) tested the effects of white mustard oil on egg lying and egg masses viability of Spodopteralittoralis. Spraying cotton plants with 2.5% of oil caused reduction in egg laying. The moths laid only 7% of their egg masses and the percentage of repellency was 89.4%. At 2.5% conc., egg masses of different ages (24, 48 and 72 h old) were highly affected and the reductions were 66.6, 45 and 92%, respectively compared to the control. Compared with the investigation of Prakash (1982),white mustard oil was found to protect stored pulses against storage insects' infestation, especially the black gram and the green gram. Regnault-Roger and Hamraoui (1995) reported that eugenol, the main constituent of the essential oil of clove, also produced a strong inhibition of larval penetration of Acanthoscelidesobtectus (Say) and finally a complete inhibition of emergence. Turcani (2001) experimented combinations of neemazal and Btk products against gypsy moth in oak stands. All combinations gave 100% mortality after three weeks of exposure. Abd El-Aziz (2001) mentioned that the treated foam with clove and eucalyptus oil vapours covering gunny sacks was the most significantly effective against C. maculatus infestation after 90 days of storage compared with the other applications (treated sacks or foam inside sacks). The foregoing results indicate that the mustard and clove essential oils have properties which cause adult mortality, repellency of B. incarnatus and this may be correlated to the chemical constituents of these oils. Application of mustard oil formulated with P. fumosoroseus on foam covering gunny bags provided promising oviposition deterrence, toxicity and suppressing B. incarnates infestation, persistence and protecting broad bean seeds from beetles' infestation for 120 days during storage (Kohler et al.1987, Maheshwari et al. 1988, Sabbour, 2012 and Madrid et al, 1990).

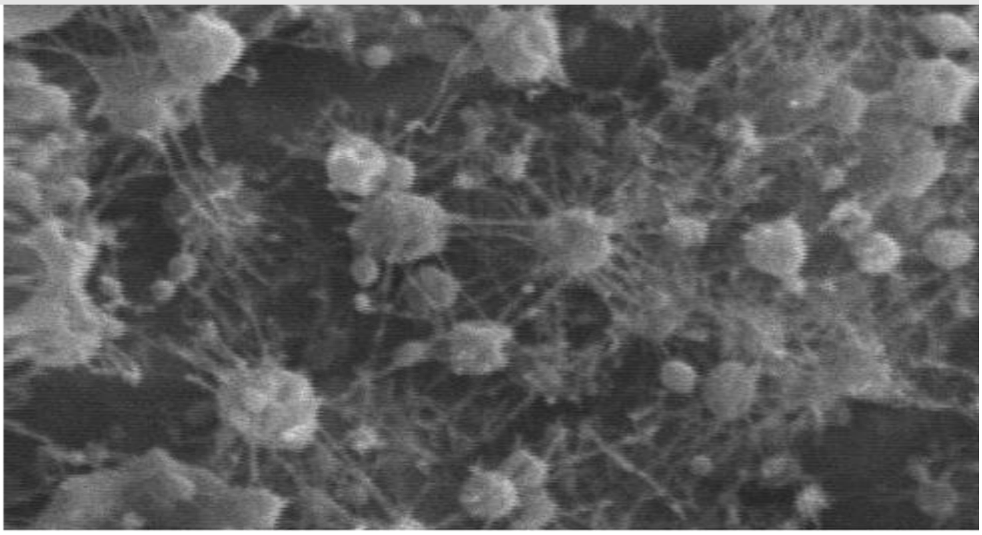

Figure 1. Scanning Electron Microscope Image of nano silica gel Cab-O-Sil-500(200 nm).

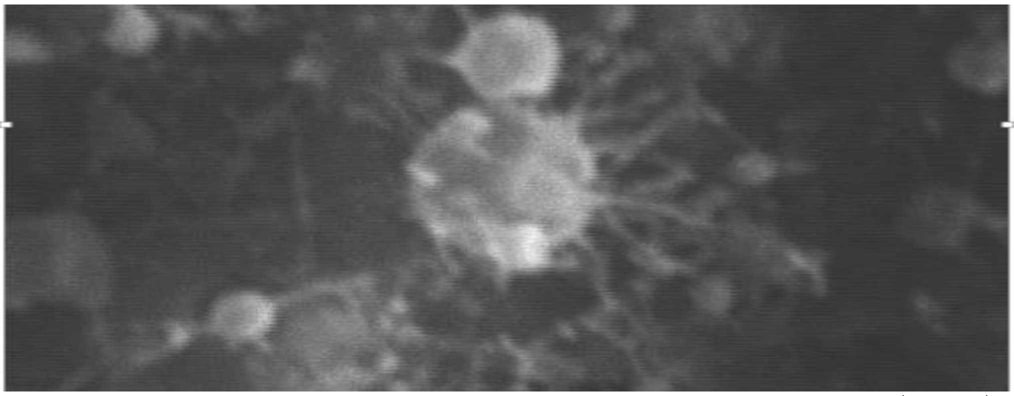

Figure 2. Scanning Electron Microscope Image of nano silica gel Cab-O-Sil-750(200 nm).

Table 1. Effect of the nanoparticlessilica gel Cab-O-Sil-500 against Sitophilus oryzae under laboratory conditions

Concentrations	No. of mortality± S.E after		
	7 Days	21D	45D
0.2%	33.2±3.1	38.3±1.7	43.6±6.1
0.5%	39.9±3.4	40.8±4.6	51.9±3.9
1%	49.1±3.8	55.4±3.0	69.7±5.3
3%	69.4±4.4	73.7±5.7	88.6±3.6
Control	1.0±2.1	1.0±2.1	2.0±1.1
F-value	14.5		
LSD 5%	13.1		

Table 2. Effect of the nanoparticlessilica gel Cab-O-Sil-750 against Sitophilus oryzae under store conditions

Concentrations	No. of mortality± S.E after		
	7 Days	21D	45D
0.2%	29.1±1.3	36.2±6.4	47.4±3.0
0.5%	40.1±5.1	48.7±4.9	50.3±5.4
1%	50.1±3.1	66.1±1.6	70.5±1.8
3%	72.6±4.3	89.9±9.5	91.2±1.6
Control	1.0±2.1	2.0±1.2	2.0±1.6
F-value	14.2		
LSD 5%	11.3		

Table 3. Accumulative mortality of Sitophilus oryzaeadults during the first weekof rice seeds exposed to treated foam with silica gel Cab-O-Sil-500 and silica gel Cab-O-Sil-750

Treated oils	Time(days)	Accumulative mortality%
silica gel Cab-O-Sil-500	0	16..1
	2	35.6
	4	47.1
	7	69.7
silica gel Cab-O-Sil-750	0	17.9
	٢	41.9
	4	75.9
untreated	0	0
	2	0
	4	0
	7	1.1

Table 4. Effect of nanoparticles on number Sitophilus oryzae of laid eggs/female and % of adult emergence (F1) of S. oryzaebeetles during storage periods of rice seeds

Storage Interval [days]	Control		silica gel Cab-O-Sil-500	
	no. of eggs /♀±S.E.	% adult emergence(F1)	no. of eggs /♀±S.E.	% adult emergence(F1)
20	79.8±8.55	92	0.0±0.0	0
40	89.2±1.32	93	0.0±0.0	0
60	91.1±5.84	94	0.0±0.0	0
80	95.2±4.42	94	0.0±0.0	0
100 %of reduction	99.3±1.41 -	97 -	5±1.1 94	5 92
120 %of reduction	97.2±1.82 -	91 -	10±0.48 91	12 90

Table 4. Effect of nanoparticles on number Sitophilus oryzae of laid eggs/female and % of adult emergence (F1) of S. oryzae beetles during storage periods of rice seeds

Storage Interval [days]	Control		silica gel Cab-O-Sil-750	
	no. of eggs /♀±S.E.	% adult emergence(F1)	no. of eggs /♀±S.E.	% adult emergence(F1)
20	88.8±5.57	92	0.0±0.0	0
40	89.2±1.32	93	0.0±0.0	0
60	96.1±4.71	94	0.0±0.0	0
80	97.6±1.72	94	0.0±0.0	0
100 %of reduction	99.1±1.43 -	97 -	6±1.0 94	5 92
120 %of reduction	99.8±1.82 -	91 -	14±1.41 91	12 90

Reduction % = [100 – No. of deposited eggs in treatment] X 100
No. of deposited eggs in control

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