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Entomotoxicity assay of two Nanoparticle Materials 1-(Al2O3and TiO2) Against Sitophilus oryzae Under Laboratory and Store Conditions in Egypt

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ABSTRACT: Two nano materials Alaminium oxide Al2O3 and Titanium dioxide (TiO2) , were tested against rice weevil *Sitophilus oryzae* (Coleoptera: Curculionidae) under laboratory and store conditions.

Results showed that Nano Al2O3 were found to be highly effective against *S. oryzae* and nano TiO2 has lower moderately effective against *Sitophilus oryzae*. Under laboratory conditions, the number of mortality of *S. oryzae* were significantly increased to 41.4±4.4, 47.8±5.8 and 50.6±3.6 individuals after treated with 3% of TiO2 after 7, 21and 45 days, as compared to 1.0 ± 2.8, 2.0 ± 5.1 and3.0 ± 3.4, respectively in the control.The effect of nanoparticles A2lO3 and TiO2 under store conditions the results showed that the nanoparticles significantly increased the number of mortality reached to 67.3 ±1.4 after 45 days of storage as compared to 3.8 ±3.8 individuals in the control . Accumulative mortality (%) of *S. oryzae* beetles increased gradually by increasing the period of exposure in case of treated foam with different tested nanoparticles Al2O3 and TiO2 Al2O3 had the highest cumulative mortality (73.3%) followed by TiO2reached to (59.7 %)after seven days.

***Keywords*:** Sitophilus oryzae**,** Titanium dioxide (TiO2) , Alaminium oxide Al2O3.

INTRODUCTION

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 Kumar et al., 2010). 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 and Owolade *et 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 (Subramanyam and Hagstrum, 1995; 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. (Edibol *et 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 exhibit different 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).

In particular, in this paper, our discussion is focused on nanoparticles in insects and their potential role in insect pest management

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 Bates 1960). After the pupal stage the adults less than 24 hrs old were used for the experiments.

Materials and Methods

Characterization of the synthesized nanoparticles were prepared according to Abduz Zahir *et al* (2012).
Lethal concentration and their associated confidence intervals were estimated from 24 h concentration mortality data using probit analysis (Finney, 1971).

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 Al2O3 and TiO2 at 1 %conc. and placed in cell A. While filter paper treated with distilled water and emulsifier only as control was placed in the cell B . 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 (Lwande *et 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 Al2O3 and TiO2 on 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 Al2O3 and TiO2, 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 applied nanoparticles 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 Al_2O_3 and TiO_2 on foam as surface protectant at 20 day intervals over 120 days. All gunny sacks (20x20 cm each) were full of heat 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 (Tapondjou et al. 2002).

RESULTS AND DISCUSSION

Data in table 1 show that under laboratory conditions, the number of mortality of *S. oryzae* were significantly increased to 41.4±4.4, 47.8±5.8 and 50.6±3.6 individuals after treated with 3% of TiO_2 after 7, 21and 45 days, as compared to 1.0 ± 2.8, 2.0 ± 5.1 and3.0 ± 3.4, respectively in the control. When *Sitophilus oryzae* were treated with Al_2O_3uder laboratory conditions, the number of mortality scored a higher mortality reached to 58.4±4.4, 68.8±0.8 and 84.6±0.7 individuals after treated with3% of Al_2O_3 nanoparticles as compared to 2.0 ±3.8, 2.3 ±5.2 and 3.1 ±3.6 individuals , respectively (Table 2) . The effect of the nanoparticles Titanium dioxide (TiO_2) against *Sitophilus oryzae* under store conditions showed in Table 3. In all treatments with Tio2, the number mortality of *S. oryzae* were significantly increased after the Tio2 treatments as compared with the control Table 3. The effect of nanoparticles A2lO3 and TiO_2 under store conditionsin tables 4 and 5, the results showed that the nanoparticles significantly increased the number of mortality reached to 67.3 ±1.4 after 45 days of storage as compared to 3.8 ±3.8 individuals in the control . Table 5 show that in the store the number of mortality of S. *oryzae* were significantly decreased to 17.1±3.6 and25.0±9.9 after 21 days of treatments with Ti02 and Al_2O_3, respectively as compared to2.0±5.9 in the control after 120 days of treatments with the nanoparticles TiO_2 39.0±5.9 and Al_2O_3 the 78.6 ±6.8as compared to5.9 ±8.9 in the control.Data in Table (6) 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 Al_2O_3 and TiO_2. Al_2O_3 had the highest cumulative mortality (73.3%) followed by TiO_2reached to (59.7 %)after seven days. In this respect, Chander and Ahmed(1986) applied different doses of the essential oil of *Acorus calamus* to seeds of green gram *Vigna radiata* (Wilcz) to protect them against *Callosobruchus chinensis* 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); Saxena *et al*.,(1976), Surabaya *et al.,* (1994).

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 7). The oviposition was completely inhibited when stored rice seeds were treated with Al_2O_3 during 20, 40, 60 and 80 days of storage. The

% reduction values in the number of laid eggs and adult emergence after 120 days were 97 and 95 93%, respectively in case of Al2O3 application on foam covering gunny bags provided promising oviposition deterrency, 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 *Spodoptera littoralis*. 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 *Acanthoscelides obtectus* (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 deterrency, 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 and Madrid *et al,* 1990).

Table 1. Effect of the nanoparticles Titanium dioxide (TiO2) against *Sitophilus oryzae* under laboratory conditions

Concentrations	No. of mortality± S.E after		
	7 Days	21D	45D
0.2%	22.3±3.4	25.3±1.9	35.7±6.4
0.5%	25.5±3.2	33.1±2.2	39.7±3.4
1%	39.1±3.6	41.4±3.8	47.7±5.2
3%	41.4±4.4	47.8±5.8	50.6±3.6
control	1.0±2.8	2.0±5.1	3.0±3.4
F-value		11.3	
LSD 5%		10.6	

Table 2. Effect of nanoparticles aluminum oxide Al2O3 against Sitophilus oryzae under laboratory conditions

Concentrations	No. of mortality ± S.E after		
	7 Days	21D	45D
0.2%	29.5±4.5	39.4±4.4	55.4±0.7
0.5%	32.3±3.4	44.4±4.4	65.8±0.8
1%	44.6±5.8	51.2±0.6	7.9±0.8
3%	58.4±4.4	68.8±0.8	84.6±0.7
Control	2.0±3.8	2.3±5.2	3.1±3.6
F-value		11.4	
LSD 5%		10.2	

Table 3. Effect of the nanoparticles Titanium dioxide (TiO2) against Sitophilus oryzae under store conditions

Concentrations	No. of mortality± S.E after		
	7 Days	21D	45D
0.2%	10.1±2.3	18.2±8.3	19.8±3.4
0.5%	22.0±3.4	30.1±4.8	38.3±5.7
1%	31.1±3.5	35.1±3.9	45.5±1.3
3%	41.22±4.5	451.1±2.5	49.9±1.1
control	1.0±2.8	2.1±3.2	3.0±8.6
F-value		10.9	
LSD 5%		10.2	

Table 4.: Effect of nanoparticles aluminium oxide Al2O3 against Sitophilus oryzae under store conditions

Concentrations	No. of mortality± S.E after		
	7 Days	21D	45D
0.2%	26.4±4.7	35.4±3.3	47.6±1.0
0.5%	35.3±4.5	43.3±4.8	58.8±1.4
1%	45.4±5.6	55.6±3.4	67.6±101
3%	51.3±4.1	63.5±1.7	87.3±1.4
control	2.2±3.8	3.3±5.6	3.8±3.8
F-value	11.8		
LSD 5%	10.3		

Table 5. Entomotoxicity Assay of the two nanoparticles materials tested against sitophilus oryzae under store conditions

Tested materials	NO. of mortality ± S.E after			
	21 D	45 D	90D	120D
TiO2	17.1±3.6	26.7±5.2	32±7.7	39.0±5.9
Al2O3	25.0±9.9	44.7±4.8	58.6±9.4	78.6 ±6.8
Untreated (control)	2.0±5.9	2.5±9.6	4.0±7.9	5.9 ±8.9
F-test =	14.5			
LSd5%=	11.4			

Table 6. Accumulative mortality of Sitophilus oryzae adults during the first week of rice seeds exposed to treated foam with different oils

Treated oils	Time(days)	Accumulative mortality%
	0	*18..3*
TiO2	2	*31.6*
	4	*41.7*
	7	*59.7*
	0	*26.7*
	2	*48.8*
Al2O3	*4*	*62.4*
	7	*73.3*
	0	*0*
	2	*0*
	4	*0*
untreated	*7*	*2.1*

Table 7. Effect of nanoparticles on number Sitophilus oryzae of laid eggs/female and % of adult emergence (F1) of B. incarnates beetles during storage periods of rice seeds

Storage	Control		Al2O3		TiO2	
Interval [days]	no. of eggs /♀±S.E.	% adult emergence(F1)	no. of eggs /♀±S.E.	% adult emergence(F1)	no. of eggs /♀±S.E.	% adult emergence(F1)
20	87.8±1.56	82	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0
40	90.2±1.39	83	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0
60	85.0±1.84	83	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0
80	92.0±1.42	90	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0
100	98.0±1.44	88	6±1.0	9	19.4±2.16	14
%of reduction	-	-	95	103	82.2	97
120	91.4±1.81	91	11±0.51	13	22.2±1.43	22
%of reduction	-	-	97	95	85	85

REFERENCES

Abd El-Aziz, Shadia E and I. A. Ismail, (2000): The effectiveness of certain plant oils as protections of broad bean against the infestation by *Bruchus incaratus. Schm.* (Coleoptera- Bruchidae) during storage. (Annals Agric. Sci , Ain Shams ,Univ. Cairo, 45 (2) ,717- 725).

Abd El-Aziz, Shadia, E., (2001): Persistence of some plant oils against the bruchid beetle, *Callosobruchus maculates* (F.) (Coleoptera : Bruchidae) during storage.(Arab. Univ. J. Agric. Sci., Ain Shams Univ. Cairo, 9(1): 423 – 432).

Abd El-Aziz Shadia E., Sharaby M. 1997. Some biological effects of white mustard oil, Brassica alba against the cotton leafworm Spodoptera littoralis (Boisd.). Anz. Schadlingskde, Pflanzenschutz, Umweltschutz 70 (3): 62–64.

Abduz Zahir, A, A. Bagavan, C. Kamaraj, G. Elango, A. Abdul Rahuman, (2012). Efficacy of plant-mediated synthesized silver nanoparticles against *Sitophilus oryzae.* JBiopest, 5 (Supplementary): 95 - 102 .

Bhattacharyya, A., Bhaumik, A., Usha Rani, P., Mandal, S. and Timothy, T.E. 2010. Nano-particles - A recent approach to insect pest control. African Journal Biotechnology, 9(24): 3489–3493.

Chander, H and S.M Ahmed, (1986): Efficacy of oils from medicinal plants as protectants of green gram against the plus beetle. *Callosobruchus chinensis.*(Entim., 11: 21-28).

Cogburn, R.R. 1980. Insect pests of stored rice. In: Rice: production and utilization, (Luh, B.S. eds).AVI Publishing Company Inc., West Port, Connecticut, USA pp 289–310.

Elibol OH, Morisette DD, Denton JP, Bashir R (2003). Integrated nanoscale silicon sensors using top-down fabrication. Appl. Phys. Lett. 83: p. 4613.

Finney, D.F. 1971. Probit Analysis, 3rd Edition, Cambridge University Press, Cambridge U.K.

Kohler, J., and J.J. Kirkland. 1987 . Improved silica-based column packing for high-performance liquid chromatography. J. Chromatogr. 385 :125-150.

Kumar, J.A., Rekha, T., Devi, S.S., Kannan, M., Jaswanth, A.`and Gopal, V. 2010. Insecticidal Activity of Ethanolic Extract of Leaves of Annona squamosa. Journal of Chemical Pharmaceutical Research, 2(5): 177–180.

Kljajic, P. and Peric, I. 2006. Susceptibility to contact insecticides of granary weevil Sitophilus granarius (L.) (Coleoptera: Curculionidae) originating from different locations in the former Yugoslavia. Journal of Stored Product Research, 42:149–161.

Larsson, S., Lundgren, L., Ohmart, C.P. and Gref, R. 1992. Weak responses of pine sawfly larvae to high needle flavonoid concentrations in scots pine. Journal of Chemical Ecology, 18: 271–282.

Leiderer P, Dekorsy T (2008). Interactions of nanoparticles and surfaces Tag der mÄundlichen PrÄufung: 25. April. URL: http://www.ub.unikonstanz.de/kops/ volltexte/2008/5387/; URN: http://nbn-resolving.de/urn:nbn:de:bsz:352-opus-53877.

Lwande W., Hassanalli A., Njorage P.W., Bentley M.D., Delle Monache F., Jondiks J.I. 1985. A new 6a-hydroxy petrocarpan with insect antifeedant and antifungal properties from the root of Tephrosia hildebrandtu. Vatle. Insect Sci. Appl. 6: 537–541.

Madrid, F.J., White, N.D.G. and Loschiavo, S.R. 1990. Insects in stored cereals, and their association with farming practices in southern Manitoba. Canadian Entomology, 122: 515– 523.

Maheshwari,H. K; M. K. Sharma and S.C. Dwivedi.(1998): Effectiveness of repelin as surface protectant against plus beetl, *Callosobruchus chinensis* infesting cowpea. (Int. j. trop. Agric. 16: 229-232).

Mulvaney, P. 1996. Surface plasmon spectroscopy of nanosized metal particles. Langmuir, 12: 788–800.

Niemeyer CM, Doz P (2001). Nanoparticles, Proteins, and Nucleic Acids: Biotechnology Meets Materials Science. Angewandte Chemie International Edition. 40(22): 4128-4158.

Nykypanchuk D, Maye MM, van der Lelie D, Gang O (2008). DNA-guided crystallization of colloidal nanoparticles. Nature, 451: 549-552.

Okonkwo, E.U. and Okoye, W.J. 1996. The efficacy of four seed powders and the essential oils as protectants of cow pea and maize grain against infestation by Callosobruchus maculates (Fabricius) (Coleoptera: Bruchidae) and Sitophilus zeamais (Motschulsky) (Coleoptera: Curculionidae) in Nigeria. International Journal Pest Management, 42: 143–146.

Owolade OF, Ogunleti DO, Adenekan MO (2008). Titanium Dioxide affects disease development and yield of edible cowpea. EJEAF Chem. 7(50): 2942-2947.

Park, I.K., Lee, S.G., Choi, D.H., Park, J.D. and Ahn, Y.J. 2003. Insecticidal activities of constituents identified in the essential oil from leaves of Chamaecyparis obtuse against *Callosobruchus chinensis* (L.) and *Sitophilus oryzae* (L.). Journal of Stored Product Research, 39: 375–384.

Prakash A. 1982. Studies on insect pests of pulses and oil seeds and their management. Ann. Tech. Report of All India Scheme of Harvest and Post – Harvest Technology, Central Rice Res. Instt., Cuttack, India, 46 pp.

Regnault-Roger C., Hamraoui A. 1995. Fumigant Toxic Activity and Reproductive Inhibition Induced by Monoterpenes on Acanthoscelides obtectus (Say) (Coleoptera), a bruchid of Kidney Bean (Phaseolus vulgaris L.). J. Stored Prod. Res. 31 (4): 291–299. Pest Control". Workshop, 10–11 February 2001, Cairo, Egypt, 25 pp.

Roy SC (2009).There's plenty of holes at the bottom: The other side of Nano. Sci. Cult. 75(1-2): 1-3.

Saxena, B. P; O. Koul and K. Tikku ,(1976): Non-toxic protectant against the stored grain insect pests. (Bull. Ger. Tech. 14: 190-193).

Shaaya E, M. Kostjukovski, J. Eilberg, and C. Sukprakarn (1997) : Plant oils as fumigants and contact insecticides for the control of stored-product insects. (J. Stored Prod Res ; 33(1):7–15) .

Surabaya, S; C. K. Babu , C. Krishnappa and K. C. K. Murty (1994): Use of locally available plant products against C*allosobruchus chinensis.*(In red gram. Mysore, j. of Agric. Sci. 28: 325-345).

Subramanyam, B.H. and Roesli, R. 2000. Inert dusts. In: Alternatives to pesticides in stored-product IPM . (Subramanyam, B. and Hagstrum, D.W. eds.). Kluwer Academic Publishers, Dordreecht, 321–380 PP.

Tapondjou L.A., Adler C., Bouda H., Fontem D.A. 2002. Efficacy of powder and essential oil from Chenopodium ambrosioides leaves as post-harvest grain protectants against six-stored product beetles. J. Stored Prod. Res. 38: 395–402.

Turcani M. 2001. The possibilities of neem Azal and its combinations with Bacillus thuringiensis var. Kurstaki use in gypsy moth (Lymantria dispar L.) populations control in Solovakia. In: "Practice Oriented Results on Use and Production of Plant Extracts and Pheromones in Integrated and Biological.

Ulrich, S. 2000. Solid-phase microextraction in biomedical analysis. J.Chromatogr. A. 902: 167-194.

Su H.C.F. 1989. Laboratory evaluation of dill seed extract in reducing infestation of rice weevil in stored wheat. J. Entomol. Sci. 24: 317–320.

Wadhwa S (2009) Nanotechnology and its Future Applications. In Chillibreeze, 25th April. Indian Talent, Global Content.

Winston, P.W. and Bates, D.H. 1960 Saturated solutions for the control of humidity in biological research. Ecology, 41(1): 232–237.