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Efficacy of inert and insecticide dusts against stored product pests *Tribolium confusum* Jaquelin du Val (Coleoptera: Tenebrionidae) and *Callosobruchus maculatus* (F.) Coleoptera: Chrysomelidae: Bruchidae) adults

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Abstract
Inert dusts (IDs), as diatomaceous earth (DE) and kaolin powders are among the most appealing alternatives to synthetic chemicals, against stored-product pests. IDs are environmentally friendly and very low toxic to mammalian. In addition, it has been proven that insects are not able to develop resistance to IDs. In this study the insecticidal activity of two IDs (DE and kaolinite) in comparison with insecticide dusts (malathion and agrothion) were evaluated at two different concentration levels 0.4 and 0.8 w/w, with the admixing wheat grain and cowpea seeds against the adults of two stored product pests cowpea beetle *C. maculatus* and confused flour beetle *T. confusum*. The results showed that the toxicity of DE, were higher than insecticide dusts and kaolinite against *T. confusum*, whereas insecticide dusts were more effective than inert dusts on *C. maculatus*. The present study suggested that DE exhibited a possibility to be an alternative to the synthetic insecticides in the management of stored product pests, especially *T. confusum.*

Keywords: stored food product, control, inert dusts, insecticide dusts, *Triboliun confusum, callosobruchus maculatus*

1. Introduction
Insects cause damage up to 40% of food grains in granaries and house stores [1]. The control of these pests primarily has relied on synthetic insecticides [2]. However, since the use of these chemicals are now restricted for their environmental and human health concerns [3, 4], in this view, alternative methods and strategies such as use of modified atmospheres, high temperatures, plant extract, microbial insecticides and inert dusts, for such synthetic chemicals are needed and has been evaluated as alternatives for the control of the stored product pests [5, 6, 7, 8].
Inert dusts (IDs) such as diatomaceous earths (DE), composed of fossilized skeletons of diatoms and kaolin powder (K) consisting principally of the mineral kaolinite, are already known as grain protestants [8]. However, a good efficacy of IDs has been proven to kill insect with minimal side effects and could be effective for the control of stored insect pests [9], thus representing among the most promising alternative to synthetic insecticides [10, 11] such as malathion and agrothion which are more hazardous to human and environment. However, the data on the efficacy of inert dusts and insecticide dusts are very scarce and more extensive research is needed.
The aim of this work is to evaluate the efficacy of DE, kaolinite and, the malathion and agrothion in comparison to their effect against the cowpea beetle *Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae: Bruchidae) and confused flour beetle *Triboliun confusum* Jaquelin du Val (Coleoptera: Tenebrionidae) which are the major pest of stored products.

2. Material and Methods
A study on the efficacy of inert and insecticide dusts against *T. confusum* and *C. maculatus* adults was conducted in the laboratory of plant protection during December 2016 to April 2017.

2. 1 Samples used
The wheat grain variety (*Triticum vulgare*) and cowpea seeds variety (*Vigna sinensis*) obtained from the market were selected for the study. The whole grain of wheat and cowpea seeds were sieved and cleaned from husks, dust or any inert materials. The conditioned samples were then stored at room temperature in sealed bags in the Laboratory of plant protection until used for the experiments.

2.2 Stored grain insects and culture preparation
Two major stored-grain insects *T. confusum* Jaquelin du Val (Coleoptera: Tenebrionidae) and *C. maculatus* (F.) (Coleoptera: Chrysomelidae: Bruchidae) were selected for the study. For culture preparation cleaned and sterilized (heating at 70 ºC for 1hr) wheat grain and cowpea seeds samples were placed in glass jars separately to reabsorb moisture. Then, transfer amounts 300 gm cowpea beans and 400 gm wheat grain to depth of 5 cm to separately sterilized culture jars. Adults of confused flour beetle and cowpea beetle (200-300 and 200-250) from previous culture were added to each jar and sealed with muslin and placed at 30 ºC ±2 and 75±5 RH. Respectively after two weeks and one week, the insects were sieved out, discarded or transferred to another jar. Adult of confused flour beetle (10-15) and

cowpea beetle (2-4) days after emergence ware used for experiment work, according to Hamid *et al*. [12].

2. 3 Inert dusts

A- Diatomite Earth (D.E)

- Commercial name: Protect-It (D. E. 90%).
- Bulk density: 0,15 gm/cm^3.
- Recommended rate: 300 gm/ton grains.
- Source: It was supplied by Agrokaslet Co. Canada.

B-Kaolinite

Kaolinite is a hydrated aluminum silicate. It is fine white or grayish-white, insoluble in water and in organic solvents, and odorless.

- Empirical formula: [$Al_4Si_4O_{10}(OH)$],
- pH: 6.1.
- Source: It was supplied by Agrokaslet Co. Canada.

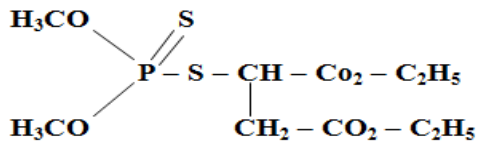
2. 3. 1 Admixing inert dusts with the wheat grains and cowpea seeds

Wheat grain and cowpea seeds were treated by inert dusts at different concentration (0.4 and 0.8 W/W) of Diatomaceous earth (90% DE) and Kaolinite. Wheat grain and cowpea seeds (each one 60 gm) were mixed manually in (0.4-Liter) glass jars separately and were divided into three equal replicates. The treated grain and seeds were infested with newly adults (10 pairs) after evaporation diethyl-ether (3 hr). Mortality percentages of confused flour beetle were recorded after one and two weeks and emergence percentages were recorded after six weeks and three months of treatment. The mean number of laid eggs were recorded for each treatment or control and placed under laboratory conditions. The emergence and reduction percentages were calculated after three weeks of treatment. Three replicates were used for each treatment and control.

2. 4 Insecticides dusts

A- Agrothion:

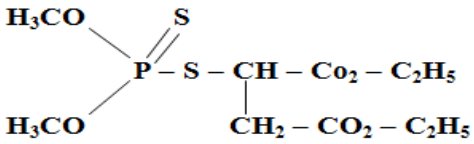
- Common name: Malathion
- Chemical name: O, O, dimethyl-S-(1, 2 dicarboxyethyl) ethyl phosphorodithioate
- Structural formula:



- Molecular weight: 330 [13].
- The applied formulation: Agrothion (Dust 1% W/W).
- Source: The active ingredient was purchased from Keminova Co., Denmark.

B- Malathion (odorless):

- Common name: Malathion
- Chemical name: O, O, dimethyl-S-(1, 2 dicarboxyethyl) ethyl phosphorodithioate
- Structural formula:



- Molecular weight: 330
- The applied formulation: odorless malathion (Dust 1% W/W).
- Source: This was purchased from Keminova Co., Denmark.

Agrothion (1%) dust and Malathion (odorless) dust (1%) was admixed at the concentration 0.04 and 0.08 W/W on wheat grain and cowpea seeds. The same other steps were accomplished as above mentioned.

3. Results

3. 1. Effect of inert and insecticide dusts admixing with wheat grain on mortality, emergence of *T. confusum* and loss of wheat after storage

The results presented in Table 1, showed the effect of inert dust (diatomite earth (DE 90%) and kaolinite) and insecticide dust (malathion (odorless) D (1%) and agrothion D (1%)) on the mortality, emergence and loss of wheat. Mortality were increased with increasing concentration, exposure period and kind of chemical, whereas in turn mean of emerged adult were decreased, respectively and the loss of wheat percentage decreased with increase of concentration level and kind of chemical.

The results indicated that mean of mortality percentage was significantly different ($P \leq 0.05$) from each other. Diatomite showed greater efficacy followed by Agrothion with mean percentage mortality 92.9 and 90.0, respectively. Percentage mortality of two concentrations and exposure times were significantly different ($P \leq 0.05$) with in treatment and control except between one week and two weeks exposure times at 0.08 concentration treated with diatomite earth and agrothion.

In case of emergence and loss of wheat%, diatomite earth treated treatments gave the lowest mean number of emerged adult and loss of wheat% (78.2 and 17.9) followed by agrothion (81.7 and 18.6), respectively. The higher number of emerged adults and loss of wheat% were given by kaolinite treated treatments (220 and 51.2) respectively and stile more was shown by control. Means of emerged adults and loss of wheat% were significantly different ($P \leq 0.05$) from each other except between diatomite earth and agrothion. Mean number of emerged adult and loss of wheat% of two concentrations and times were significantly different ($P \leq 0.05$) with in treatment and control according to LSD < 0.05 presented in Table 1.

Table 1: Effect of inert and insecticide dusts admixing with wheat on mortality, emergence of *T. confusum* and loss of wheat after storage

Dusts	Conc. %	Mortality % after			Mean of emerged adults after			Loss of wheat %		Reduction (%)
		1 week % ± SD	2 weeks % ± SD	mean	6 week % ± SD	3 months % ± SD	mean	%± SD	mean	
Control	…….	0.0±0.0	2.3±2.1	1.6a	153.2±4.0	523.0±6.5	337.8d	70.0±1.2	70.0d	---------
Diatomite Earth (DE 90%	0.4	82.3±1.9	89.3±2.1	92.9e	30.0±1.5	225.0±6.3	78.2a	30.3±3.3	17.9a	56.6

	0.8	100.0± 0.0	100.0±0.0		15.2±1.2	41.2±2.2		5.3±0.2		92.2
Kaolinite	0.4 0.8	20.0±0.0 23.2±1.9	53.2±1.8 55.0±0.0	37.9b	118.5±5.5 106.0±4.0	385.6±8.2 273.0±5.8	220.3c	56.4±2.8 45.3±1.2	51.2c	24.8 47.4
Malathion (odorless)D (1%)	0.4 0.8	60.0±3.0 71.6±4.2	81.6±2.1 91.4±1.3	76.3c	49.2±2.2 44.2±3.1	255.0±8.2 181.0±6.6	132.3b	38.2±2.2 31.8±2.1	35.1b	51.0 65.4
Agrothion D (1%)	0.4 0.8	81.6±1.4 93.2±1.8	88.2±1.8 96.8±1.5	90.0d	42.0±1.3 7.3±1.1	229.0±9.9 49.0±3.5	81.7a	31.0±5.1 5.8±1.0	18.6a	56.1 90.6
LSD≤ 0.05	A B C			2.25 1.41 3.78			11.20 9.23 20.13		2.00 5.41	

*The mean followed by the same letters are not significantly different at P ≤ 0.05.
*Angular transformation was done for the percentage values.
*A LSD for the effect of different dusts comparisons.
*B LSD for the effect of different concentrations comparison (0.04 and 0.08 %).
*C LSD for the effect of different time comparison (1 week and 2 weeks or (6 weeks and n months)).

3. 2. Effect of inert and insecticide dusts admixing with cowpea seeds on egg laying and emergence of *C. maculatus* adults

The results obtained for the egg laying and emergence of adults after treatment with inert dusts (diatomite earth (DE (90%) and kaolinite) and insecticide dusts (malathion (odorless) D (1%) and agrothion D (1%)) are shown on Table 2. There was no any number of eggs laid in the malathion and agrothion treated treatments. Diatomite earth showed more effect to egg laying and emergence of *C. maculatus* adults compared with kaolinite, that gave lowest mean number of eggs laid (175.0 and 34.2) and emerged adults (72.0 and 18.6) at 0.04 and 0.08% concentrations, respectively. Kaolinite showed less effect to egg laying, which gave highest mean number of eggs laid (278.0 and 209.0) at 0.04 and 0.08% concentrations and still more in control (335.2), but it had no any control effect on emergence% of adults that showed higher percentage of emergence (63.8 and 70.5%) at 0.04 and 0.08% concentrations, respectively followed by control (57.3%). Mean of eggs laid, emerged adult, emergence% and reduction% treated with used chemical were significantly different (P ≤ 0.05) from each other except between malathion and agrothion.

The results indicated that insecticide dusts were more effective than inert dusts. In the diatomite earth and kaolinite treated treatment the number of eggs laid was decreased and emergence% percentage was increased with increasing of concentration level (Table 2).

Table 2: Effect of inert and insecticide dusts admixing with cowpea seeds on egg laying and emergence of *C. maculatus* adults

Dusts	Conc. % W/W	mean no. of laid eggs		Mean no. of emerged adults		Emergence %	Reduction %	
		± SD	mean	± SD	Mean		± SD	mean
Control	……	335.2± 10.6	335.2^{d}	192.0± 11.9	192.0^{d}	57.3	----------	--------
Diatomite Earth (DE (90%))	0.04 0.08	175.0± 8.8 34.2± 7.2	104.6^{b}	72.0± 8.3 18.6± 2.1	45.3^{b}	41.1 54.4	62.5± 1.6 90.3± 0.3	76.3^{b}
Kaolinite	0.04 0.08	278.0± 7.2 209.0± 6.6	243.5^{c}	177.2± 10.6 147.0± 9.9	162.2^{c}	63.8 70.5	7.6± 2.4 23.3± 8.3	15.6^{c}
Malathion (odorless) D (1%)	0.04 0.08	0.0± 0.0 0.0± 0.0	0.0^{a}	0.0± 0.0 0.0± 0.0	0.0^{a}	0.0 0.0	100.0± 0.0 100.0± 0.0	100.0^{a}
Agrothion D (1%)	0.04 0.08	0.0± 0.0 0.0± 0.0	0.0^{a}	0.0± 0.0 0.0± 0.0	0.0^{a}	0.0 0.0	100.0± 0.0 100.0± 0.0	100.0^{a}
LSD ≤ 0.05	A B		16.9 7.3		20.4 8.3			3.03 1.8

*The mean followed by the same letters are not significantly different at P ≤ 0.05.
*Angular transformation was done for the percentage values.
*A LSD for the effect of different dusts comparisons.
*B LSD for the effect of different concentrations comparison (0.04 and 0.08 %).

4. Discussion

Regard to the effect of inert dust and insecticide dust in this research, the toxicity of diatomite earth were higher than insecticide dusts and kaolinite against *T. confusum,* and insecticide dusts were more effective than inert dusts on *C. maculatus*. Earlier study also showed that toxicity of tested compound varied with insect species [14]. In the present study diatomite earth, which showed higher toxicity than insecticide dusts against *T. confusum*, can be replaced instead the insecticide dusts for the control of stored product pests. It can sufficiently protect the stored products from the insects; also it is environmental safe than insecticide dusts and reduce the danger due to resistance as malathion resistance in stored-product insect-pests, which has been reported from all over the world [15, 16, 17]. Diatomaceous earth (DE) has extremely low toxicity to mammals [18]. Previous studies also demonstrated that the diatomaceous earths have been shown to be successful for the management of different stored grain insect pests and can be replaced with the conventional insecticides [19], but their overall efficacy depends upon different factors, such as type and concentration of DE, grain moisture content, temperature, insect species, insect density and type of grain commodity [20, 21, 22, 23].

DE has been tested for stored grain pest control by numerous investigators [24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35]. DE kills insects with its abrasive qualities disrupting the insect water barrier and by removing or absorbing the epicuticular lipid layers causing excessive water loss through the cuticle [36].

5. Conclusion

Regard to the effect of inert dust and insecticide dust, in this research the toxicity of diatomite earth were higher than insecticide dusts and kaolinite against *T. confusum*, whereas insecticide dusts were more effective than inert dusts on *C. maculatus*. In the present study diatomite earth, which showed higher toxicity than insecticide dusts against *T. confusum*, can be replaced instead the insecticide dusts for the control of stored product pests. It can sufficiently protect the stored products from the insects, also it is environmentally safe than insecticide dusts and reduce the danger due to resistance as malathion resistance in stored-product insect-pests.

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7. References

1. Matthews GA. Insecticide application in the stores. In: Application technology for crop protection (eds. Matthews GA, Hislop EC. 360. CAB International, Wallingford, UK, 1993.
2. Shayya E, Kostjukovski M, Eilberg J, Sukprakarn C. Plant oils as fumigants and contact insecticides for the control of stored product insects. J Stored Prod. Res. 1997; 33:7-15.
3. Bakkali F, Averbeck S, Averbeck D, Idaomar M. Biological effects of essential oils-a review. Food Chem. Toxicol. 2008; 46:446-475.
4. Boyer S, Zhangand H, Lempérière G. A review of control methods and resistance mechanisms in stored-product insects. Bull. Entomol. Res. 2012; 102:213-229.
5. Banks HJ, Fields JB. Physical Methods for Insect Control in Stored-grain Ecosystem. In: Stored Gain Ecosystem, Jayas, D.S., N.D.G. White and W.E. Muir (Eds.). Marcel Dekker, New York, 1995, pp: 353-409.
6. Athanassiou CG, kavllieratos NG, Meletsis CM. Insecticidal effect of three diatomaceous earth formulations, applied alone or in combination, against three stored-product beetle species on wheat and Maize. J of stored product research. 2007; 43:330-334.
7. Campolo O, Verdone M, Laudani F, Malacrinò A, Chiera E, Palmeri V. Response of four stored products insects to a structural heat treatment in a flourmill. J Stored Prod. Res. 2013; 54:54-58.
8. Campolo O, Malacrinò A, Zappalà L, Laudani F, Chiera E, Serra D, Russo M, Palmeri V. Fumigant bioactivity of five citrus essential oils against Tribolium confusum. Phytoparasitica. 2014; 42:223-233.
9. Permual D, Patourel Le G. Laboratory evaluation of acid activated kaoline to protect stored paddy against infestation by stored product insects. J of stored products research. 1992; 26:139-153.
10. Bedini S, Flamini G, Girardi J, Cosci F, Conti B. Not just for beer: Evaluation of spent hops *(Humulus lupulus)* as a source of eco-friendly repellents for insect pests of stored foods. J Pest. Sci. 2015; 88:583-592.
11. Regnault-Roger C, Vincent C, Arnason JT. Essential oils in insect control: Low-risk products in a high-stakes world. Annu. Rev. Entomol. 2012; 57:405-424.
12. Hamid MAK, Kashyap CS, Cauwenberghe RV. Control of grain insects by microwave power. Journal of Microwave Power. 1968; 3(3):126-135.
13. Anonymous. Induced mutations for disease resistance in crop plants II (Proceedings FAO/IAEA advisory group meeting. Vienna, 1980). Vienna: IAEA. 1983a.
14. Samir AM, Abdelgaleil Magdy IE, Mohamed Mohamed EI, Badawy Sailan AA, El-arami. Fumigant and contact toxicities of monoterpenes to Sitophilus oryzae (L) and Tribolium castaneum (Herbst) and their inhibitory effects on acetylcholinesterase activity. J chemical Ecol. 2009; 35:518-525.
15. Rassman W. Insecticides resistance in stored products pests. Gesunde Pflanzen 1988; 40:39-42.
16. Sayaboc PD, Acda MA. Resistance of the major coleopterous pests of stored grain to malathion and pirimiphosmethyl. Philippine Entomologist. 1990; 8:653-660
17. Zettler JL, Cuperus GW. Pesticide resistance in Tribolium castaneum (Coleoptera: Tenebrionidae) and Rhyzopertha dominica (Coleoptera: Bostrichidae) in wheat. J Econ. Entomol. 1990; 83:1677-1681.
18. Subramanyam BH, Hagstrum DW. Resistance Measurement and Management. In: Integrated Mnagement of Insect in Stored Products, Subramanyam, B. and Hagtrum, D. W., (Eds.). Marcel Decker, New York, ISBN: 1-42005-361-2, 1995, pp: 331-398.
19. Islam MdS, Hasan MdM, Lei C, Mucha-Pelzer T, Mewis I, Ulrichs C, *et al*. Direct and admixture toxicity of diatomaceous earth and monoterpenoids against the storage pests Callosobruchus maculatus (F.) and Sitophilus oryzae (L.). J Pest Sci, 2009. DOI: 10.1007/s10340-009-0276-7
20. Korunic Z. Rapid assessment of the insecticidal value of diatomaceous earths without conducting bioasssays. J Stored Prod. Res. 1997; 33:219-229.
21. Rigaux M, Haubruge E, Fields PG. Mechanisms for tolerance to diatomaceous earth between strains of Tribolium castaneum (Coleoptera: Tenebrionidae). Entomologia Experimentalis and Applicata. 2001; 101:33-39.
22. Fields P, Allen SZ, McLaughlin A, Stathers T. Standardised testing for diatomaceous earth. In: Credland, P.F., Armitage, D.M., Bell, C.H., Cogan, P.M, 2003, 163.
23. Korunic Z, Fields P. Susceptibility of three species of Sitophilus to diatomaceous earth.: In: Lorini, I., Bacaltchuk, B., Beckel, H., Deckers, D., Sundfeld, 171 E., P. D. S. J., Biagi, J. D., Celaro, J. C., Faroni, L. R. D. A., Bortolini, L. D. O. F., Sartori, M. R., Elias, M. C., Guedes, R. N. C., Da Fonseca, R. G., Scussel, V. M. (Eds), Proceedings of the Ninth International Working Conference on Stored Product Protection, 15-18 October 2006, Campinas, Brazil, Brazilian Post-harvest Association, Campinas, Brazil, 2006.
24. Parkin EA. Control of granary weevil with finely ground mineral dusts. Ann. Applied Biol. 1944; 31:84-88.
25. LaHue DW. Evaluation of Malathion, Synergized Pyrethrum, and Diatomaceous Earth as Wheat Protetants. In small bins, 1965, pp. 1-13.
26. LaHue DW. Insecticidal dusts: Grain protectants during high temperature-low humidity storage. J Econ. Entomol. 1978; 71:230-232.

27. LaHue DW, Fifield CC. Evaluation of FOUT inert dusts on wheat as protectants against insects in small bins, 1967, pp. 1-24.
28. Redlinger LM, Womack H. Evaluation of four inert dusts for the protection of shelled com in Georgia from insect attack. United States Department of Agriculture, Agricultural research Service, ARS. 1996; 51:7-25.
29. McGaughey WH. Diatomaceous earth for confused flour beetle and rice weevil control in rough, brown, and milled rice. J Econ. Entomol. 1972; 65:1427-1428.
30. Desmarcheilier JM, Dines JC. Drycacide treatment of stored wheat: its efficacy against insects, and after processing. Australian Journal of Experimental Agriculture. 1987; 27:309-312.
31. Aldryhim YN. fficacy of the Amorphous Silica Dust, Dryacide, against Tribolium confusum Du v and Sitophilus granarius (L.) (Coleoptera: Tenebrionidae and Curculionidae. J Stored Prod. Res. 1990; 26:207-210.
32. Aldryhim YN. Combination of classes of wheat and environmental factors affecting the efficacy of amorphous silica dust, Dryacide, against Rhyzoppertha dominica (F.). J. Stored Prod. Res. 1993; 29:271-275.
33. Subramanyam B, Swanson CL, Madamanchi N, Norwood S. Effectiveness of Insec to, a new diatomaceous earth formulation, in suppressing several stored-grain insect speices, 1994, pp. 1-26. S1. Paul, Minnesota: University of Minnesota
34. McLaughlin A. Laboratory trials on desiccant dust insecticides. Proceedings of the 6th International Working Conference on Stored product Protection. 1994; 2:638-659.
35. Xie YS, Field PG, Isman MB. Repellency and toxicity of Azadirachtin and Neem concentrates to three stored product beetles. J Econ. Entomol. 1995; 88:1024-1031.
36. Mewis I, Appel HM, Hom A, Raina R, Schultz JC. Major signalling pathways modulate Arabidopsis glucosinolate accumulation and response to both phloem feeding and chewing insects. Plant Physiology. 2005; 138:1149-1162.