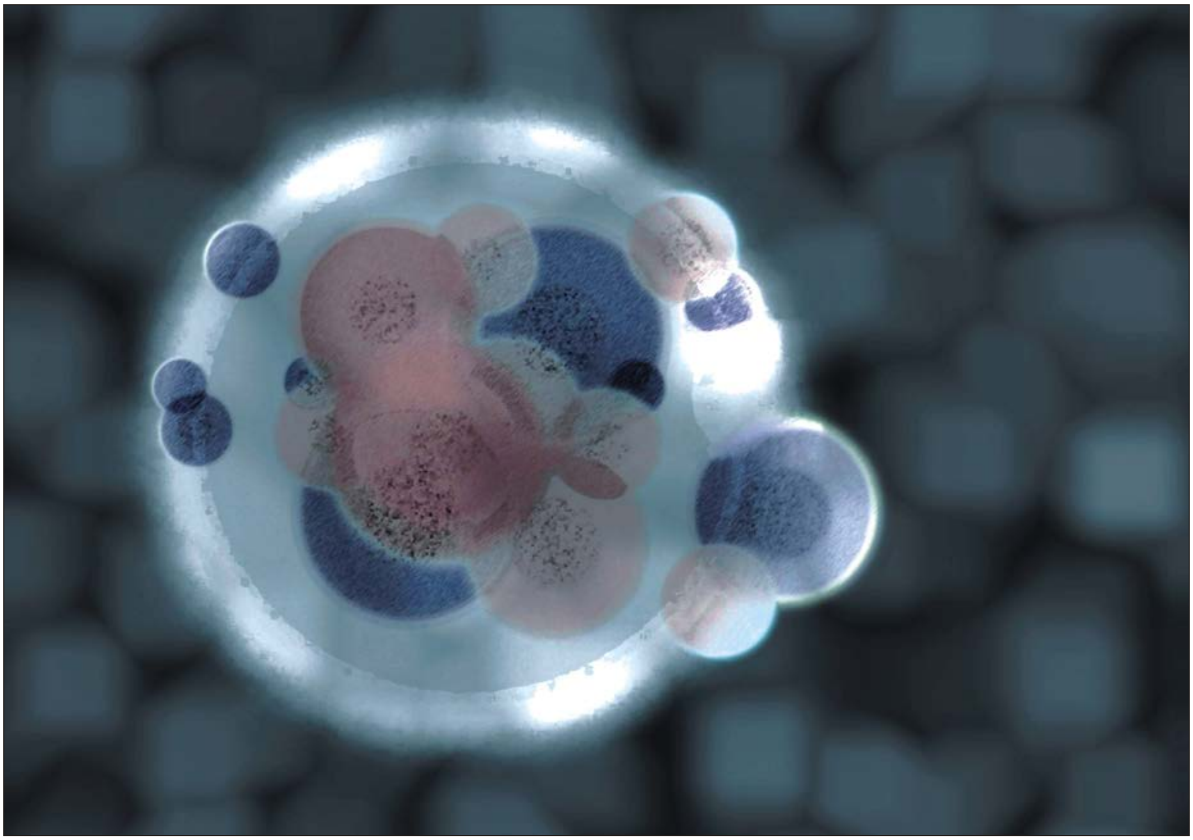

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Toxicity Studies of Some Inert Dusts with the Cowpea Beetle, *Callosobruchus maculatus* (Fabricius) (Coleoptera: Bruchidae)

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Abstract: The present study has been undertaken to find out the effectiveness of DE and some other inert dusts like, kaolin powder, paddy husk ash, coal ash, alluvial soil, china clay and a dust formulation insecticide carbaryl on the cowpea beetles *Callosobruchus maculates* (F.). The bioassay of the dusts was done on adult beetles by applying them with normal food. The LD_{50} of *C. maculatus* after 24 h was 737.15, 73305.15, 1479.29, 11449.60, 117371.50, 5171.79 and 21.49 ppm for diatomaceous earth, kaolin powder, paddy husk ash, coal ash, alluvial soil, china clay and carbaryl, respectively. The LD_{50} after 48 h was 385.24, 12078.10, 974.11, 7433.71, 10650.42, 1168.22 and 11.25 ppm for diatomaceous earth, kaolin powder, paddy husk ash, coal ash, alluvial soil, china clay and carbaryl respectively. The order of toxicity of the insecticides was carbaryl > diatomaceous earth > paddy husk ash > china clay > coal ash > alluvial soil> kaolin powder.

Key words: Diatomaceous earth, *Callosobruchus maculates,* carbaryl, kaolin, inert dust

INTRODUCTION

Inert dusts have various industrial and agricultural uses and the important one is as insecticide dust diluents and carriers (Ebeling, 1971). Watkins and Norton (Watkins and Norton, 1947) provide a classification of the inert dusts used as diluents and carriers. Inert dusts are used to control insect pests of field crops, stored products and animals (Mel'zina *et al*., 1982). Inert dusts used in stored-product protection can be categorized into 4 groups (Banks and Fields, 1995). The 1st group consists of clays, sand, paddy husk ash and wood ash. This group also includes volcanic ash, which has been shown to possess insecticidal properties (Edwards and Schwartz, 1981). The 2nd group consists of a great number of minerals such as dolomite, magnesite, copper oxychloride, katelsous (rock phosphate and ground sulfur), lime (calcium hydroxide), limestone (calcium carbonate) and common salt (sodium chloride) (Golob, 1997). These minerals have been tested in the past and seem to offer some protection to stored grains from insect attack at rates greater than 10 g kg^{-1} of grain (Jenkins, 1940; Parkin, 1944; Gay *et al*., 1947). Some of these minerals may be suitable for stored-product protection in underdeveloped countries (Golob and Webley, 1980). They are rarely used on bulk-stored grain in developed and developing countries, because of the large amount of material needed to obtain commercial kill of insect pests. The 3rd group consists of dusts that contain synthetic silica (silicon dioxide). These materials are light and hygroscopic and are produced by drying an aqueous solution of sodium silicate (Quarles, 1992). The 4th group consists of dusts that contain natural silica, such as Diatomaceous Earth (DE), which are made up fossilized skeletons of diatoms. Many DE dusts are now commercially available and used in many developed and developing countries for managing stored-product insects and mites (Korunic, 1998; Cook and Armitage, 1999; Ling *et al*., 2000; Mewis and Reichmuth, 2000), or to improve fumigation efficiency (Bridgeman, 2000).

Fields (Fields, 2000) described some of the advantages and limitations in detail. Inert dusts have low mammalian toxicity. They are stable on the grain and provide protection as long as the dusts remain dry. Unlike organophosphate grain protectants, they do not leave toxic residues. Grain treated with inert dusts can be cleaned prior to milling to remove most of the dust particles (Desmarchelier and Dines, 1987). Insects exposed to inert dusts are subjected to desiccating and other physiological stresses (Adrien, 1968; Vrba *et a*l., 1983; Howard *et al*., 1995). The most widely accepted explanation for the action of inert dusts is that they kill arthropods by removing or absorbing the epicuticular lipid layers causing excessive water loss through the cuticle (Ebeling *et al*., 1961; Tarshis, 1959; Tarshis, 1960; Tarshis, 1961). Wigglesworth (1947) suggested that the inert dusts are more effective in removing the epicuticular lipids in parts of the insects that rub against each other.

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Table 1: LD_{50}, 95% confidence limits and regression equations of tested dust applied in mixed formulation with food to adult *Callosobruchus maculatus*

Dust	LD_{50} (ppm)	95% confidence limits Lower (ppm)	Upper (ppm)	Regression equations	χ^2 (at 4 df)
24 h					
DE	737.15	571.61	950.63	Y= -2.383655 + 2.574895X	3.269
Kaolin powder	73305.15	36855.64	145802.30	Y= -2.130305 + 1.465593X	0.629
Paddy husk ash	1479.29	1366.72	1601.13	Y= -17.60899 + 7.132053X	2.472
Coal ash	11449.60	3890.49	33695.78	Y= 0.2504544 + 1.170188X	0.616
Alluvial soil	117371.50	2028.08	6792642.00	Y= 2.657707 + 0.4620307X	0.019
China clay	5171.79	3100.88	8625.73	Y= -0.1217785 + 1.37918X	1.931
Carbaryl	21.49	17.21	26.84	Y= 1.90733 + 2.321165X	1.332
48 h					
DE	385.24	310.11	478.57	Y= -2.483249 + 2.89405X	3.138
Kaolin powder	12078.10	8449.04	17265.91	Y= -1.54989 + 1.604581X	0.874
Paddy husk Ash	974.11	867.72	1093.55	Y= -11.7653 + 5.609747X	2.076
Coal ash	7433.71	3705.05	14914.77	Y= 0.088885 + 1.268627X	0.314
Alluvial soil	10650.42	2212.99	51256.96	Y= 2.738928 + 0.5614268X	0.192
China clay	1168.22	789.16	1729.34	Y= 0.9734979 + 1.312623X	5.078
Carbaryl	11.25	9.03	14.02	Y= 1.878487 + 2.968569X	7.020

Inert dusts, especially DE dusts and silica gels are suitable for disinfesting empty storage facilities and for grain treatment. Their use is more appealing in view of the widespread development of resistance in stored-product insects to conventional pesticides. On grain, different treatment techniques (treating partial layers) should be explored. Locally available different inert dusts are easily available and initiatives should be given to develop insecticides with these materials. In the present study the effectiveness of DE and some other inert dusts were used to test the toxicity on the adult bruchid beetle, *Callosobruchus maculatus* (F.).

MATERIALS AND METHODS

The weevil *C. maculates* used in experiments was collected from a private store house of Shaheb Bazar, Rajshahi. The cultures were maintained in the Crop Protection and Toxicology Laboratory, Department of Zoology, University of Rajshahi. Mass cultures were maintained in earthen pot and sub-cultures in glass jars or beakers with the food medium. All the equipments were kept in an oven for sterilization, about 6 h at 60°C. Cowpea seeds were used as food medium through the experiment. A huge number of beetles were thus reared to set a continuous supply of the newly formed adults.

A sample of SilicoSecs was obtained from Agrinova GmbH (Germany). SilicoSec is a relatively new DE formulation of freshwater origin and contains approx. (92%) SiO_2, 3% Al_2O_3, 1% Fe_2O_3 and 1% Na_2O. Dry lumps of kaolin was purchased from the market. The lumps were crushed in boiling distilled water and then homogenized. The preparation was left to cool at 29°C. It was then filtered through a 53 µm mesh sieve, a piece of 45 µm fine steel gauze and a piece of cotton fabric (25 µm of fine-knit). The resulting suspension, called kaolin milk (Kéïta *et al*., 2000), was left undisturbed for 3 days and protected from dust with a fine steel gauze. The particulates were recovered by draining. The water and they were placed in the sun to dry (still under the steel gauze). The dried material was crushed in a porcelain mortar and the powder was sifted (53 µm mesh) and stored in a container away from moisture.

Paddy husk and coal ashes were collected from rice mills and brickfields, respectively. The ashes were sieved with a fine net (mesh 600) and placed in an incubator for an hour at 60°C to dry up excessive moisture. Alluvial soil was collected from the riverbed of the Padma. The china clay was procured from the market. Both soil and clay were powdered in a mortar and pestle and finally meshed and dried. For comparison the insecticidal activity of the inert dusts, a commercial insecticide dust formulation Sevin 85 SP of Bayer Cropscience was used.

The bioassay was done on adult beetles by applying them with normal food. The doses were 50, 100, 200, 400, 800 and 1600 ppm for DE; 5000, 10000, 20000, 30000, 40000 and 50000 ppm for kaolin powder; 800, 1000, 1200, 1400, 1600 and 1800 ppm for paddy husk ash; 1000, 2000, 3000, 4000, 5000 and 6000 ppm for coal ash; 100, 500, 1000, 2000, 4000 and 8000 ppm for alluvial soil and china clay and 5, 10, 20, 30, 40 and 50 ppm for carbaryl. The mortality of the beetles was recorded 24 and 48 h after treatment. The mortality percentage was corrected using Abbott's formula (Abbott, 1925). Probit analysis was done according to Finney (Finney, 1947)using a software developed in the Department of Agricultural and Environmental Science, University of Newcastle upon Tyne, UK.

RESULTS AND DISCUSSION

The LD_{50} of DE, kaolin powder, paddy husk ash, coal ash, alluvial soil, china clay and carbaryl on *C. maculatus*

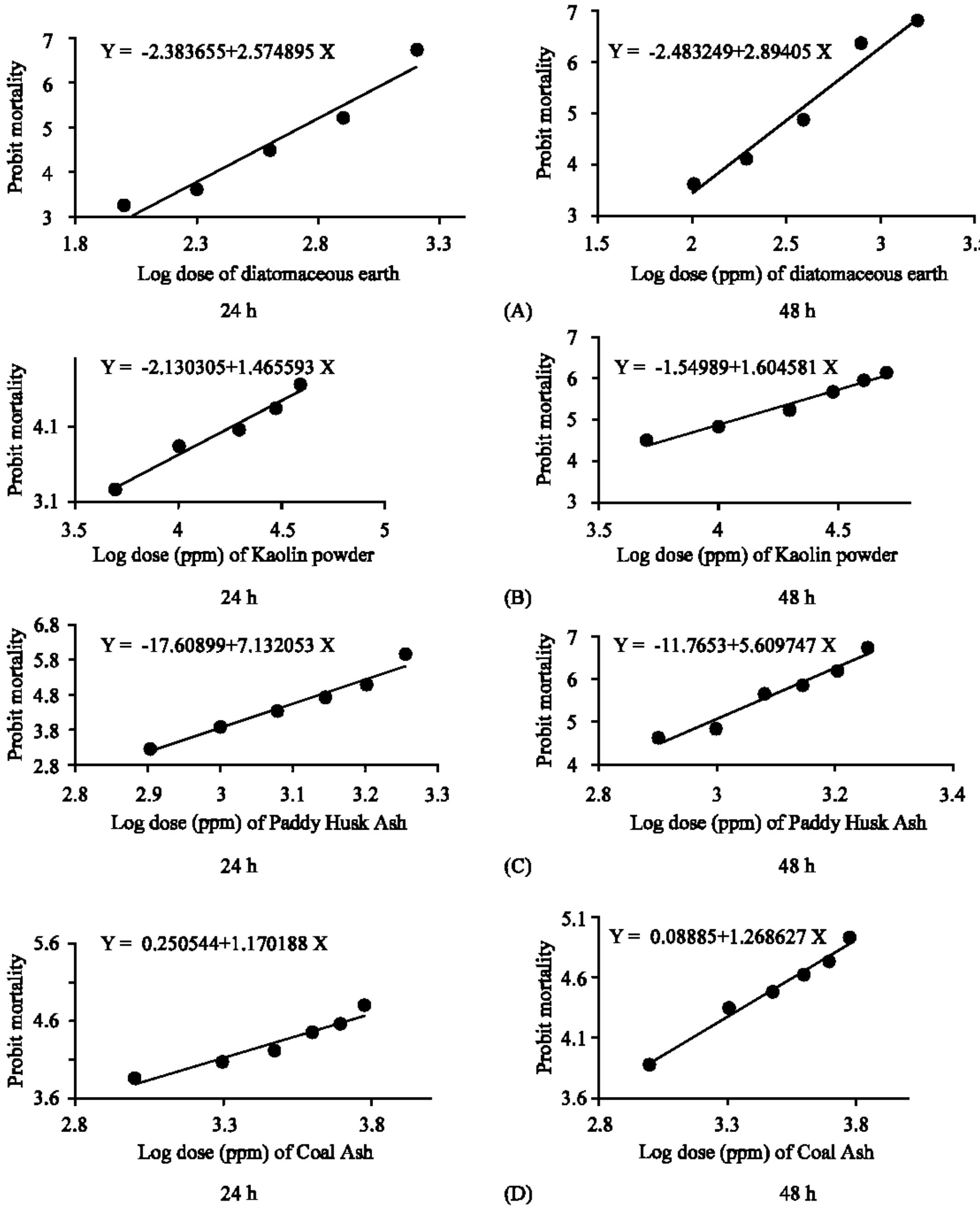

Fig. 1: Probit mortality line of (A) Diatomaceous Earth, (B) Kaolin powder, (C) Paddy husk ash and (D) Coal ash on adult *C. maculatus*

after 24 h was 737.15, 73305.15, 1479.29, 11449.60, 117371.50, 5171.79 and 21.49 ppm, respectively. The order of toxicity was carbaryl > DE > paddy husk ash > china clay > coal ash > kaolin powder > alluvial soil. The LD_{50} after 48 h was 385.24, 12078.10, 974.11, 7433.71, 10650.42, 1168.22 and 11.25 ppm for DE, kaolin powder, paddy husk ash, coal ash, alluvial soil, china clay and carbaryl, respectively and the order of toxicity was carbaryl > DE > paddy husk ash > china clay > coal ash > alluvial soil> kaolin powder. The results indicate that carbaryl was the most toxic and kaolin powder was the least toxic to adult *C. maculatus*. The regression lines of probit mortality on different doses of the used inert dusts are presented in Fig. 1 and 2.

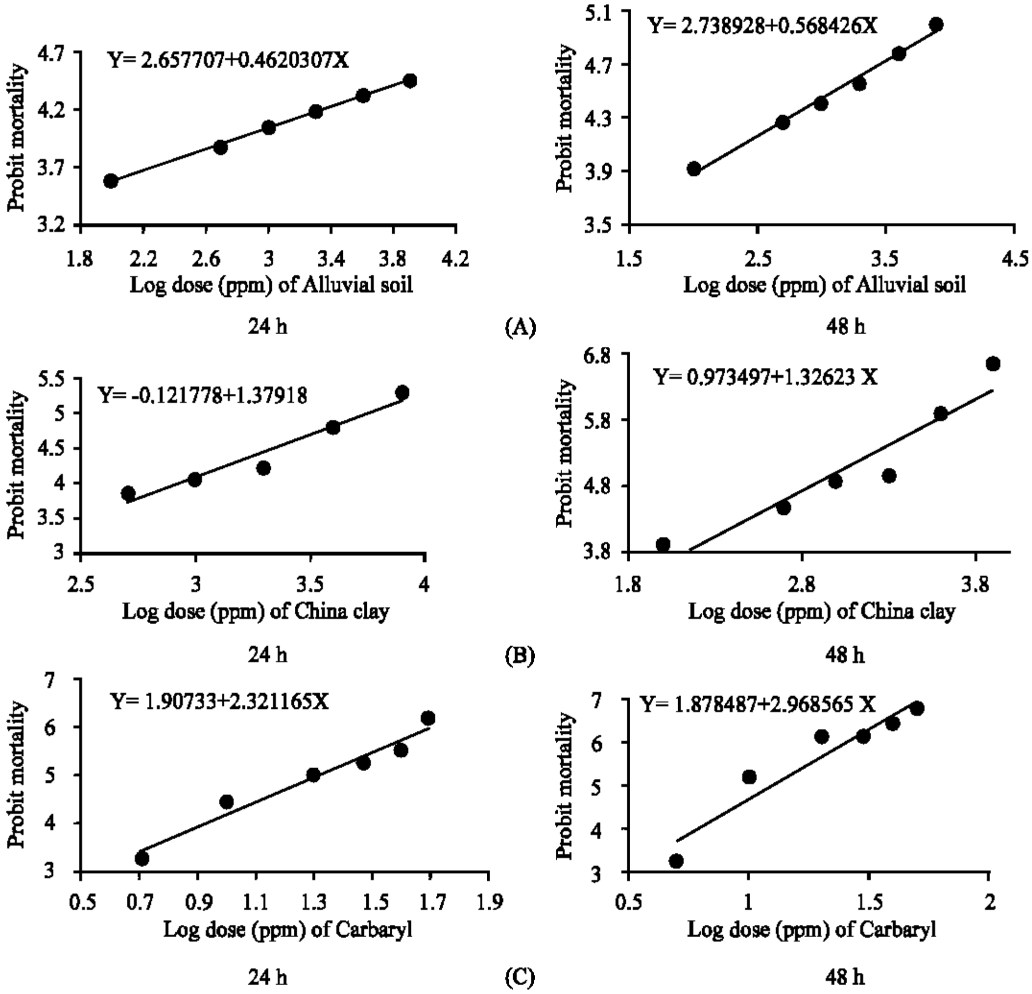

Fig. 2: Probit mortality line of (A) Alluvial soil, (B) China clay and (C) Carbaryl on adult *C. maculates*

The efficacy of inert dusts against insects, including DE, depends greatly on the physical properties of the dust. These properties include particle size distribution, active surface and oil adsorption, the diameter of inner pores of particles, moisture content of dust, SiO_2 content (Ebeling, 1971; Chiu, 1939; Chiu, 1939; Alexander *et al*., 1944; David and Gardiner, 1950; Maceljski *et al*., 1970; Maceljski and Korunic, 1972) or the diameter of diatom particles (Quarles, 1992; McLaughlin, 1994; Subramanyam *et al*., 1994). Ideally, active DEs should have a high amorphous silicon dioxide content with a uniform particle size (less than 10 μm in diameter), that contain very little clay and other impurities (Quarles, 1992). The analysis of physical and chemical properties of DE is time-consuming and expensive and can be conducted only by experts at specially equipped laboratories. Therefore, in the past, bioassay was considered the most important criterion for the assessment of the efficacy of DE against insects (Subramanyam *et al*., 1994). These methods are relatively expensive and time-consuming since they require an expert and a well-equipped entomological laboratory.

Use of dusts to control arthropod pests in stored products is not new. Sand, clay and ash have been used for centuries (Quarles, 1992). Zacher (Zacher, 1937; Zacher, 1937) was the first since 1900 to study this topic. He described the mode of action of inert dust and metal oxides on insects (Zacher and Kunike, 1931). Diatomaceous earths are amorphous dusts and are no longer considered hazardous to human health in contrast to crystalline dusts, if they are used correctly and exposure time is short (Ferch *et al*., 1987). The product SilicoSec® was first approved for use in Germany in 1997. Natural and artificial preparations are applied as dusts, spray powder, suspensions or granules.

Panday and Verma (Pandey and Varma, 1977) tested attapulgite dust as a protectant against the cowpea weevil, *C. maculatus* on black gram at the rate of

10-50 g kg^{-1} at 27°C and 75% RH. Complete mortality was obtained at an application rate of 50 g kg^{-1} after 48 h. In the present investigation it was considered the possibility of using DE and other inert dusts or insecticidal dust formulations used to protect stored grain from insect attack. Formulations of this type would have the advantages of reducing levels of toxic residues and of having greater activity against insect populations with low levels of resistance to the chemical component of the formulation.

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