EVALUATION OF INSECTICIDAL POTENTIALS OF NIGERIAN RAW DIATOMACEOUS EARTH

Baba Gana J. Kabir[1]*, Ahmodu Bukar[1], Hauwa T. Abdulrahman[2] and Farouk M. Gambo[1]
[1]Department of Crop Protection, Faculty of Agriculture, University of Maiduguri, P. M. B. 1069, Maiduguri, Borno State, Nigeria
[2]Department of Biological Sciences, Faculty of Science, University of Maiduguri, P. M. B. 1069, Maiduguri, Borno State, Nigeria

*kabir@unimaid.edu.ng. Presenting and corresponding author. Tel. +234 802 6798714

Introduction

One natural product that has had increasing use in pest control is diatomaceous earth (DE), which composed of fossilized diatoms. Diatomaceous earths (DEs) are very promising alternatives to traditional residual insecticides and fumigants, with very low mammalian toxicities. In stored-product protection, DEs have proved effective as grain protectants and structural treatments to storage facilities. Insecticidal activity of DEs is principally due to dehydration of insects caused by the damage of the cuticular layers of the integument.

The vast majority of compressed, soft chalky rock deposits of DE are from the Eocene/Miocene epochs. DE is prepared for commercial use by quarrying, drying and milling. The only change to DE during this process is the reduction in the moisture content and mean aggregate particle size. The result of this process is a fine, talc-like dust, with the mean particle size distribution from 0.5 to more than 100 µm (the majority from 10 to 50 µm.

There are numerous deposits of DE in Nigeria. However their insecticidal properties were not sufficiently investigated. The objective of this study was to evaluate the insecticidal efficacy of Bularafa raw DE against four stored-product insect species.

Methods

The experiments were conducted under ambient laboratory conditions (27 - 34°C and 43 -58 % relative humidity). The insects C. *maculatus*, *O. surinamensis R. dominica* and *T. castaneum* used in these study were came from laboratory cultures maintained for over a year. *Callosobruchus maculatus* was bioassayed on cowpea grains and the other three species on wheat grain. The raw diatomaceous earth (DE) was obtained from DE mines in Bularafa village, Gujba Local Government Area, Yobe State, Nigeria. The raw DE was milled and sieved to obtain a powdery consistency. The fine powder was analyzed for p^H and tapped density in accordance with method describe by Korunic (1997). While mineral composition were

analyzed in the Mineralogy Laboratory of the Department of Geology, University of Maiduguri by X-ray florescence method on Minimate (Panalytical Company, UK). The physico-chemical characteristics of the raw DE are as follows: The raw DE has the following properties: tapped density – 312.5 g/L, pH-9.2; mineral composition: SiO_2 - 28.7%, Al_2O_3 -12.6%, CaO – 26.5%, Na_2O – 11.6%, K_2O - 9.3%, FeO - 0.9%, ZnO - 0.33%, CuO - 0.18%, MnO - 0.55% and LOI(loss on ignition) -1.76%.

The grains were treated at dose rate of 0 (untreated control) 250, 500, 750, 1000, 1500 mg raw DE/kg. The commercial DE product Protect-It (Hedey Technologies Inc. Canada) at 1000 mg/kg served as positive control (PC). Fifty grams samples of the untreated control and treated grains were placed in 250 ml capacity jars, and 30 mixed-sex *O. surinamensis* adults were place into jar. The same procedure was repeated for *R. dominica, T. castaneum* and *C. maculatus*. Each treatment was replicated three times. Mortality of the exposed adult was observed after 7 and 14 days, except for C. maculatus; in which case it was conducted after 3 and 5 days. The number of F1 progeny was assessed after 40 days. Data were corrected for mortality using the Abbott's (Abbott, 1925) formula. Then arcsine or square root transformed and submitted to Analysis of variance. Differences between treatment means were determined using the Tukey-Kramer HSD Test at 5%levevl of probability.

Results and discussion

Results are showed in table 1- 3. Insect mortalities increased with dose rate and exposure time. After 7 d of exposure Raw DE was most effective against O. surinamensis causing >70% mortality at 500 mg/kg and 100 mortality at the 1500 mg/kg. In contract even at the highest dose of raw DE, *R. dominica, and T. castaneum* sustained 83.3 and 78.9 % mortality, respectively. Only after 14 days, raw DE applied at 750mg/kg caused > 90% mortality in the three species. Raw DE at the highest dose rate caused 100% adult mortality in *O. surinamensis and R. dominica* and was generally comparable the positive control (Protect-It at 1000 mg/kg).

All treatment significantly reduced progeny production in *O. surinamensis, R. dominica and T. castaneum*. However complete progeny suppression was not noted except in the case of O. surinamensis on grain treated at highest dose of raw DE. In contrast, Protect-It as 1000 mg/kg completely prevented adult progeny emergence in all the three species.

In the case of C. maculatus on cowpea, same trend as with the preceding species was observed. In this case after 3 d of exposure adult mortality ranged from 46.7 to 83.3 %. Complete adult mortality was observed only at 1500 mg/kg of raw DE or the positive control following a 5 d exposure time. With C. maculatus Progeny suppression range from 72.3 to 97.3%. Complete progeny suppression was noted only for the positive control.

The results of the present study showed that the Bularafa raw DE has appreciable insecticidal properties. However dose rates higher than 1500 mg/kg of grain

commodity may be required for effective stored-product insect control. Further studies involving enhancement of the raw \de with more potent substances and field evaluation are recommended.

Table 1. Percent mortality of three stored product insect species exposed to different doses of raw DE

Exposure period	Raw DE dose (mg/kg)	Insect species		
		O. surinamensis	*R. dominica*	*T. castaneum*
7d	0	2.2± 1.1d	2.2± 1.1e	1.1± 1.1e
	250	43.5±7.2c	20.9±2.7d	23.8±2.9d
	500	90.0±1.9b	65.6±4.4c	46.7±3.8c
	750	95.5±2.2ab	70.0±1.9c	50.0±3.9 c
	1000	98.9± 1.1ab	80.0± 1.9b	58.9± 2.9c
	1500	100.0± 0.0a	83.3± 2.9b	78.9± 2.9b
	PC	100±0.0a	100±0.0a	89.7±2.7a
14 d	0	4.0±1.1d	4.4±1.1 c	3.3±1.9d
	250	70.3±3.9c	59.3±6.7b	48.9±8.3c
	500	93.3±1.9b	91.1±2.9a	84.4±2.9b
	750	98.9± 1.1a	93.3± 1.9a	91.1± 1.1b
	1000	100.0±0.0a	97.8±2.2a	92.8±1.1b
	1500	100.0±0.0a	100.0±0.0a	98.9±1.1a
	PC	100±0.0a	100±0.0a	100±0.0a

Within each exposure period, means within a column followed by same letter are not significantly different using the Tukey-Kramer HSD test, at 5% level of probability

Table 2. Progeny production of three stored product insect species exposed to different doses of raw DE

Raw DE Dose (mg/kg)	Insect species					
	O. surinamensis		*R. dominica*		*T. castaneum*	
	No. of progeny	% Progeny suppression	No. of progeny	% Progeny suppression	No. of progeny	% Progeny suppression
0	51.7±1.9a	-	113.7±16.4a	-	54.3±2.9a	-
250	12.3±3.2b	76.2	78.2±6.7b	31.2	12.7±2.7b	76.6
500	5.7±0.9b	89.0	22.0±3.6c	80.7	10.7±0.9b	80.3
750	1.3±0.9c	97.5	10.0±0.6d	91.2	6.7±6.7bc	87.7
1000	0.7±0.7d	98.6	7.7±1.9de	93.2	4.7±4.7bc	91.3
1500	0.0±0.0d	100	4.0±0.6e	96.5	2.0±2.0c	96.3
PC	0.0±0.0	100	0.0±0.0	100	0.0±0.0	100

Within each column, means followed by same letter are not significantly different using the Tukey-Kramer HSD test, at 5% level of probability

Table 3. Percentage mean mortality of *C. maculatus* adults and progeny production after exposure to various doses of raw DE

Raw DE dose (mg/kg)	% Mean mortality		Progeny production	
	3d	5d	No. of progeny	% progeny suppression
00	1.7±1.7e	12.5±3.3d	56.0±0.4a	-
250	46.7±3.3d	65.8±4.7c	15.5±0.6b	72.3
500	56.7±6.7cd	70.8±3.2bc	13.0±1.0b	76.8
750	65.2±3.6c	81.3±6.2b	13.9±3.3b	75.2
1000	77.5±1.9b	93.3±1.3b	4.5±0.6c	92.0
1500	88.3±2.9a	100.0±0.0a	1.5±0.3d	97.3
PC	91.7a	100.0a	0.0±0.0e	100.0

Within each column, means followed by same letter are not significantly different using the Tukey-Kramer HSD test, at 5% level of probability