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Evaluation of Efficacy of Marble Dust for the Control of *Sitophiluszeamais* Motsch. Coleoptera: Curculionidae of Stored Maize

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Abstract

Evaluation of efficacy of marble dust for the control of maize weevil (*Sitophiluszeamais*) was carried out in the laboratory, Department of Biology, Federal University of Technology Owerri. The mean laboratory temperature ranged from 27^{0}C to 30^{0}C and mean relative humidity 81% to 85%. The experimental design used was completely randomized design (CRD) replicated four times with four treatments. The treatments were 0g, 40g, 80g and 120g of marble dust. The result showed that 120g (2) of marble dust significantly reduced the number of weevils (*Sitophiluszeamais*) introduced for 8 weeks in the laboratory, followed by 80g (17) of marble dust, 40g (19) of marble dust and the least was control 0g (30) of marble which there was no death of weevil recorded. The analysis of variance (ANOVA) showed that 120g of marble dust was significantly high in percentage mortality rate of the maize weevils and mean number of holes (perforation of the seeds) at probability of 0.05 levels. The chemical analysis showed that proportion of metallic ions in the marble dust indicated no poisonous heavy metals like Cadmium II oxide (Cd^{2+}) and lead II ($Pb^{2+)}$ in this study. The marble dust would not pose a health threat to man and could be used as alternative insecticide for the storage of stored products.

Keywords: Marble dust, chemical analysis, alternative insecticide, stored pest.

1. Introduction

The maize weevil is a small snout beetle which varies in size. It varies from dull red-brown to nearly black and is usually marked on the back with four light reddish or yellowish spots. The maize weevil has fully developed wings beneath its wing covers and can fly readily (Iken & Amusa, 2014). The thorax is densely pitted with somewhat irregularly shaped punctures, except for a smooth narrow strip extending down the middle of the dorsal (top) side. An egg hatches in a few days into a soft, white, legless, fleshy grub which feeds on the interior of the grain kernel (Obi, 2017). The grub changes to a naked white pupa and later emerges as an adult beetle. The rate of development is slightly slower for the maize weevil than for the rice weevil. A minimum of thirty days is required for passing through the egg, larval and pupal stages. The maize weevil is slightly larger than the rice weevil and has more distinct colored spots on the forewings. It is a stronger flier than the rice weevil (Haines, 1991).

The habits and life cycle are similar to the rice weevil. These are indications that processed products that are made of cereals could be attacked by insect pests like *Sitophilus* that are primary pests of cereals. *Sitophiluszeamais* motschulsky is a serious pest of stored cereals. It attacks grains in the field and its infestation is carried into the store where it continues its destructive activities (Haines, 1991). Pasta factories can be infested by insects, leading to negative economic and commercial consequences. Infestations can occur during the storage process in industries or in warehouses, general stores and retail shops already infested by insects feeding on other products (Stejskal, Kucerova & Lukas, 2004; Trematerra & Suss, 2006; Trematerra, Valente & Kavallieratos, 2007; Trematerra & Suss, 2006; Murata, Imamura & Miyanoshita,. 2008). To prevent insect contamination, it is important to understand when, where, and how insects invade food products; because olfactory sense in *S. zeamais*plays an important role on the infestation of a food product (Trematerra, 2009).*Sitophiluszeamais* Motschulsky is a serious pest of stored cereals. It attacks grains in the field and its infestation is carried into the store where it continues its destructive activities (Haines, 1991). Recently, Babarinde, Sosina and Oyeyiola (2008) reported that *S. zeamais*can infest non-cereals like yam and cassava chips. Owing to the economic importance attached to grains especially cereals in Nigerian agriculture, it became necessary to protect the grains and cereal grain products against damage by insect pests. The population dynamics of *Sitophilus* species is favoured in food materials that have more than 10% water content (Haines, 1991). They affect processed food materials and the nutritive content of the food materials by lowering their components (Bamaiyi, Dike & Onu, 2007). Voracious feeding on whole grains by this insect causes product weight loss, fungal growth, quality loss through an increase in free fatty acids and it can even completely destroy stored grains in all types of storage systems/facilities. Invasion by this primary coloniser may facilitate the establishment of secondary and mite pests and pathogens. *S. zeamais*is an invader and enters packages (e.g. commercial rice or pasta) through existing openings that are created from poor seals, openings made by other insects or mechanical damage (Murata, Imamura & Miyanoshita, 2008). This tarnishes brand image to the consumers, thus resulting in serious economic damage to food companies.

Many farmers and grain producers in Sub-Saharan Africa are frequently forced to sell their produce earlier than they would wish to (Subramanyam & Hagstrum, 1996) because of the lack of appropriate pest control strategies. This is also coupled with the lack of sufficient funds to run appropriate pest control programs, which, in many cases involve the use of synthetic insecticides that are expensive to the ordinary farmer (FAOSTAT, 2015). Synthetic insecticides that are currently being used by many farmers include Actellic Super Dust, Malathion and Pirimiphos-methyl. The active ingredients in this group of insecticides are phosphorylated organic compounds. These pesticides are imported organophosphates aimed at controlling stored grain products (IITA, 2012). The concern by many farmers in the continued use of synthetic pesticides is based on insecticide residues in their food, unavailability of pesticides on the market, reduced efficacy of these pesticides due to increased resistant strains in many insects (Subramanyam & Hagstrum, 1996). Resistance has been observed in a number of insect pests including *Rhizoperthadominica*, *Triboliumcastaneum* to pimiphos-methyl (Mvumi & Giga, 1993) and some organophosphates (Taylor, 1996). The red flour beetle (*T.casteneum*) and the saw-toothed grain beetle has also been seen to be resistant to deltamethrine and cabaryl respectively (Mvumi & Giga, 1993). *R. dominica*, *T. casteneum* and *P. truncates* have been found to be less susceptible to synthetic insecticides which upon continuous use have resulted in resistance development (Ebeling, 2004). Bromos and Malathion are more effective on some insect species but weak on *R.dominica* and *T.casteneum*. The continued use of synthetic chemicals on stored grain is a major worry to many farmers. This is due to their unaffordability and as a result many farmers are abandoning using these synthetic insecticides on their stored grain.

2. Materials and Methods

2.1. Study Area

The study was carried out in the Department of Biology laboratory, Federal University of Technology, Owerri. Owerri is located in the tropical rainforest zone of Nigeria with average rainfall distribution of 2250-2800mm. The laboratory condition has a temperature range of 27 – 30^{0}C and relative humidity (RH) of 81 – 85 %.

2.2. Experimental Design and procedure

The experimental design used was Completely Randomized Design (CRD), replicated four times with four treatments given a total of sixteen plates of maize grain in the laboratory. Maize grain and maize weevil (*Sitophiluszeamais* Motsch.) were procured from Ekeonunwa market in Owerri, Imo state. Maize grains (Var: 8434-11) which had not been treated with insecticide were purchased and marble dust was obtained from Owerri town and sieved with 90 micron mesh sieve (serial number: DIN 4188) and kept in air-tight container until used. 250g of maize grain was weighed and placed in each plastic container with various grams of marble dust of 0g, 40g, 80g and 120g respectively, covered with plastic net and held with rubber band. In each plate, 30 maize weevils were introduced to test the effectiveness of the marble dust for eight weeks in the laboratory on mortality rate, mean number of holes (perforation index) and weight loss of maize grain and the dead maize weevils were observed, counted and recorded.

2.3. Laboratory Analysis

Chemical analysis of marble dust was conducted using atomic absorption spectrophotometer (Pye Sp. 9). The sample solution was prepared following with the procedure of Association of Official Analytical Chemist (A.O.A.C, 1990).

2.4. Data Analysis

Data obtained were subjected to analysis of variance (ANOVA) procedure and the means were separated using least significant difference (LSD) at 0.05% probability level.

3. Results

3.1. Mortality Rate of Maize Weevil (*Sitophiluszeamais*) on Marble Dust

The mortality rate was recorded high on 120g of marble dust having percentage mortality of 93.33% and was significantly higher than other treatments applied at different levels of 80g (43.33%), 40 (36.67%) and 0g (0.0%) respectively at P=0.05 level. The results also showed that 40g and 80g marble dust did not differ significantly in mortality of *Sitophiluszeamais*

(Table 1). There was no mortality recorded on maize seeds that were not treated with marble dust.

Table 1: Effect of marble dust on maize weevil mortality

Marble dust (g)	Mean number introduced(weevils)	Mean number dead	Mean number Alive	Percentage Mortality
0	30± 0.01 [a]	0±0.00 [c]	30±0.01 [a]	0.00± 0.00 [c]
40	30±0.01[a]	11±0.16 [b]	19±1.23 [b]	36.67±2.29 [b]
80	30±0.01 [a]	13±0.18 [b]	17±1.20 [b]	43.33±2.34 [b]
120	30± 0.01 [a]	28±0.21 [a]	2±0.03 [c]	93.33±3.01 [a]

Mean along the column having different superscript of letters differ significantly at P=0.005 level

3.2. Mean perforation number of maize seeds treated with marble dust

Table 2 shows the results on the mean number of holes and weight loss of maize grain treated with different grains of marble dust. 120g of marble dust gave the lower mean number of holes (41) and with lower weight loss of 4.9g on seeds. The maize seeds not treated with marble dust gave the highest mean number of holes (211) and the highest weight loss (25.5 g) of the seeds.

Table 2: Effect of marble dust on mean number of holes and weight loss of maize grain.

Marble dust (g)	Initial weight 0f seeds(g)	Final weight of seeds (g)	Mean number of holes	Weight loss of seeds (g)
0	250± 0.01[a]	224.5± 12.01[c]	211±20.16[a]	25.5± 3.23[a]
40	250± 0.01[a]	234.2± 19.12[b]	98± 11.03[b]	15.8±2.07[b]
80	250± 0.01[a]	239.3±19.22[b]	87±8.24[b]	10.7±1.62[c]
120	250± 0.01[a]	245.1±22.14[a]	41±4.35[c]	4.9±0.98[d]

Mean along the column having different superscript of letters differ significantly at P= 0.05level

3.3. Content of metallic ions in the marble dust

The result on metallic ion content of the marble dust shows that the poisonous heavy metals like lead 11 and cadmium 11 oxides were absent. Calcium ion (17.61%) was the most common in the dust followed by Iron (II) (5.58%), aluminum (5.50%), Zinc (II) (4.36%), magnesium (0.706), potassium (0.26%) and Sodium (0.20%) respectively (Table 3).

Table 3: Proportion of metallic ions in the Marble dust

Cations	%
Calcium (Ca^{2+})	17.610
Iron (II) (Fe^{3+})	5.583
Magnesium (Mg^{2+})	0.706
Aluminum (Al^{3+})	5.503
Sodium (Na^{+})	0.204
Potassium (K^{+})	0.258
Cadmium II oxide (Cd^{2+})	ND
Lead II (Pb^{2+})	ND
Zinc II (Zn^{2+})	4.362
Copper II (Cu^{2+})	2.562

ND= Not detected.

4. Discussion

The consequences of environmental pollution, increasing cost insecticides and the growing problem of insect resistance has caused pest management practioners to evaluate inert dusts for the control of stored product insects (Golob, 1997; Muyinza, 1998). This study agreed with the work of Golob (1997) that studied on current status and future perspective for inert dusts for control of stored products. Unlike the silica-based inert dusts such as diatomaceous earths and silica aerogels, non-silica inert dusts such as lime is less expensive, readily available and have been used traditionally in developing countries (Golob, 1997). In a field simulated trial with maize in Malawi, Gerald (2008) observed that dolomite (a carbonate of calcium and magnesium) at the rates of 1%, 5%, 15% and 30% restricted insect infestation of the stored maize. Also in India, Banerjee, Naziddom and Sertiar (1985) reported 100% mortality of the rice weevil, *Sitophilusoryzae* (L) and the lesser grain borer, *Rhizoperthadominica* (F) after 10 days.

The effectiveness of marble dust (a none – silica inert dust) against *Sitophiluszeamais* Motsch., a major field to stored pest of maize in Nigeria was tested in this study and the chemical analysis of the marble dusts showed no poisonous chemical that could pose a health threat to man.

5. Conclusion

The evaluation of efficacy of marble dust for control of maize weevil showed that 120g of marble dust gave a high mean number of dead weevils with high percentage mortality rate of *Sitophiluszeamais*. The metallic ions present in marble dust were not poisonous. The poisonous cadmium II and lead II were not present and therefore, marble dust is safe for the control of *S. zeamais* in this study and could therefore be used as alternative insecticide for storage of stored products in Nigeria.

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