Effect of zeolite on the development of *Sitophilus zeamais* Motsch

Y. Haryadi *, R. Syarief†, M. Hubeis†, and I. Herawati§

Abstract

Zeolite is a mineral substance found in Indonesia. It is usually used as an additive to animal feeds. The present study was conducted to evaluate the insecticidal effects of zeolit for insect control during storage of maize.

It was shown that 5% zeolite by weight was able to kill 100% of *Sitophilus oryzae* (L.) during 3 months of storage. A 4% dose of zeolite reduced the population of insects after 6 weeks exposure. The experiments suggested that natural zeolite was more effective than activated zeolite against *S. oryzae*.

Introduction

Maize is the second staple food in Indonesia. It is also a major component of animal feeds and a raw material for the corn oil industry. The consumption of maize as food increased from 2.7 Mt in 1982 to 2.9 Mt in 1993. During the same period, the use of maize in animal feeds has also increased, from 2.4–2.7 Mt. During storage and distribution, maize is often attacked by various storage pests. One of the most destructive pests commonly found in Indonesia is *Sitophilus zeamais* Motsch. Several techniques, including fumigation, have been adopted to control the development of this pest.

The use of natural substances as grain protectants is very limited. With the growing concern about the negative effects of synthetic insecticides, the use of natural insecticides should be encouraged. Studies on the insecticidal effects of natural substances such as charcoal and clays have been reported (Majumder et al. 1959; Majumder and Krishnamurthy 1960), but none on the insecticidal effects of zeolite dust.

Zeolite belongs to the mineral substances abundantly found in Indonesia, and has been used so far in agriculture, i.e., to improve the properties of soil and as an additive in animal feed. According to Mumpton (1988), zeolite contains SiO_4 and AlO_4, with hardness number of 3.0–3.5 in Moh's scale. Important physical properties of zeolite dust are its abrasiveness and water adsorption capacity. Hence, it may have insecticidal effects.

The present study was conducted to evaluate the use of zeolite as grain protectant to control the development of maize weevil *Sitophilus zeamais* Motsch.

*Inter University Center for Food and Nutrition, Bogor Agricultural University, P.O. Box 122, Bogor 16001, Indonesia.

† Food Technology Development Center, Bogor Agricultural University, P.O. Box 160, Bogor 16001, Indonesia.

§ Banjarbaru Agricultural Research Station, Banjarbaru, South Kalimantan, Indonesia.

Materials and Methods

Materials

Two varieties of maize were used in the study, i.e., Genjah Kretek and Kalingga. The former is a local variety, whereas the latter belongs to the hybrid variety. Samples of both varieties, grown at Bogor Agricultural Research Station, were sun dried immediately after harvest, shelled, and sent to the laboratory. In the laboratory, the maize grains were heated at 40–45°C for 6 hours to bring the moisture content to about 11% and kill any pests present in the samples. The zeolite was ground and sieved to obtain zeolite dust of 80 mesh. Part of it was then heated at 200°C for 6 hours to remove the moisture. This heated zeolite was called active zeolite, while the unheated material was called natural zeolite.

The 14 + 7 days old *Sitophilus zeamais* were drawn from standard laboratory culture maintained on maize grains at laboratory condition (27–30°C; 75–85% r.h.). To obtain adults of specific age the following method was used. Stock culture was sieved thoroughly to remove all adult weevils. The culture was returned to the culture room and incubated. Using this method, the age of adult weevils which emerged the next day and thereafter was known.

Methods

First experiment

Glass bottles of 200 g capacity were filled with 150 g of maize grains. Active zeolite dust was then added to the grains in the bottles at dosages of 0, 5, 10 and 15% by weight. The bottles were shaken thoroughly. Ten pairs unsexed weevils were released to each glass bottle. The bottles were covered with muslin cloth tied with rubber bands, and were stored at laboratory conditions of temperature and humidity. The bottles of each dose were divided into three groups to be observed after 4, 8 and 12 weeks of storage. The experiment was replicated three times. Observations were made on insect mortality, germinability of grains and grain moisture content.

Second experiment

Glass bottles were filled with 20 g maize grains of Kalingga variety. Zeolite dust was added to the grains in the bottles at dosages of 0, 4, 8 and 12% by weight. Both active and natural zeolite were used in this experiment. To each bottle, 10 pairs of unsexed weevils were added. Without removing the parent weevils, grain samples were held in the laboratory for six weeks. At the end of the storage, progenies and parent weevils were counted. The experiment was replicated three times.

Results and Discussion

First experiment

The results of the experiment showed that zeolite dust was effective as a grain protectant against *S. zeamais* (Table 1).

Table 1. Mortality of *S. zeamais* at different level of zeolite.

Dose of zeolite (%)	Period of storage (weeks)		
	4	8	12
0	13.2 b	18.8b	12.3 b
5	100.0 a	100.0 a	100.0 a
10	100.0 a	100.0 a	100.0 a
15	100.0 a	100.0 a	0 a

Means within column followed by the same letter are not significantly different (DMRT; p = 0.05)

Table 1 indicates that after four weeks of storage the mortality was 100%. The same result was obtained after 12 weeks of storage. This indicated that the weevils were not able to produce progeny. The weevils probably died before they could oviposit. The abrasive characteristics of zeolite dust and its water adsorption capacity might be the cause of insect mortality.

Determination of viability is very important, especially if the grain is going to be used as seed. To evaluate any effect of zeolite on seed viability, the germinability test was performed. The results indicated that even after 12 weeks the grains still showed high germinability .

Table 2. Germinability of maize grains

Dose of zeolite (%)	Period of storage (weeks)		
	4	8	12
0	98.7 c	89.3 b	71.8 b
5	98.7 bc	97.8 a	96.2 a
10	99.7 ab	98.9 a	97.6 a
15	100.0 a	98.9 a	97.8 a

Means within column followed by the same letter are not significantly different (DMRT; p = 0.05)

The germinability of grains without zeolite was reduced to 71.8% after 12 weeks of storage, while that with 5% zeolite treatment was still above 95%. This may correlate with the moisture content of grains as shown in Table 3. After 12 weeks, moisture content of grains without zeolite treatment was 14.7%, while that with 5% zeolite treatment was still below 14 %, although it had increased from the initial moisture content of 11.0%. The Canadian Grain Commission recommends 14% as a maximum moisture content for maize in Canadian grading system, while the USDA recommends a moisture content of maize for normal U.S. grades of 14.1% (Bushuk and Lee 1978). The present study shows that, in addition to its function as grain protectant to control the development of weevils, zeolite dust could maintain the moisture content of grain below the maximum recommended moisture content. Low moisture content, in turn, maintains the germinability of grains.

Second experiment

The results of the second experiment showed that after one generation the total adult population of *S. zeamais* in maize without zeolite treatment was 69.3 (Table 4). The addition of 4% zeolite dust reduced the total adult population to 26.2. As in the first experiment, zeolite dust was effective in controlling the development of *S. zeamais*. The results of the second experiment suggest that natural zeolite was more effective than active zeolite. For example, at 8% and 12% levels of natural zeolite, there were no adult emergences after 6 weeks of incubation, while with active zeolite the total adult populations were 31.7 and 27.3, respectively.

Table 3. Moisture content of maize grains

Dose of zeolite (%)	Period of storage (weeks)		
	4	8	12
0	11.8 a	13.1 a	14.7 a
5	11.2 b	12.7 b	13.7 b
10	11.4 ab	12.3 b	13.3 bc
15	11.4 ab	12.3 b	13.0 c

Means within column followed by the same letter are not significantly different (DMRT; p = 0.05)

Table 4. Total adult population of *S. zeamais* after six weeks in maize treated with natural and active zeolite.

Dose of zeolite (%)	Type of zeolite dusts		
	Active	Natural	Means
0	69.3	69.3	69.3 a
4	32.0	20.3	26.2 b
8	31.7	20.0	25.8 b
12	27.3	20.0	23.7 b

Means within column followed by the same letter are not significantly different (DMRT; p = 0.05)

Natural zeolite was more effective than active zeolite probably because it more readily adheres to the bodies of the weevils, due to the moisture content of the dust. However, further investigation is needed to confirm this. In a previous study (Majumder and Krishnamurthy 1960) activation of clays was done by chemical methods using hydrochloric acid.

Acknowledgment

The authors would like to thank the Director of Bogor Agricultural Research Station for supply of maize samples.

References

Bushuk, W. and Lee, J.W. 1978. Biochemical and functional changes in cereals:maturation, storage and germination. In: Hultin, H.O., and Milner, M., ed., Posharvest biology and biotechnology. Food and Nutrition Press, 1–33.

Majumder, S.K. and Krishnamurthy, K. 1960. Bleaching earths as insecticides. Journal of Scientific and Industrial Research, 19C(1), 29–30.

Majumder, S.K. Narasimhan, K.S. and Subrahmanyan, V. 1959. Insecticidal effects of activated charcoal and clays. Nature, 184, 1165–1166.

Mumpton, F.A., 1988. Development of uses for natural zeolites. A critical commentary. In: Kallo, D. and Sherry, H.S., ed., Occurence, properties, and utilization of natural zeolites. Budapest, Akademiai Kiado, 333–366.