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Diatomaceous Earth for Confused Flour Beetle[1] and Rice Weevil[2] Control in Rough, Brown, and Milled Rice[3,4]

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ABSTRACT

A diatomaceous earth produced 100% mortality in rice weevils, *Sitophilus oryzae* (L.), and confused flour beetles, *Tribolium confusum* Jacquelin duVal, exposed for 21 days in rough rice treated with dosages of 1.75 and 3.5 g/kg, respectively. Milled and brown rice required dosages of 3.5 and 5.25 g/kg, respectively, to effect 100% rice weevil mortality. More than 56 days were required to effect 100% mortality in confused flour beetles in brown rice treated with 7.0 g/kg. Lower mortalities in milled and brown rice appeared to result from saturation of the diatomaceous earth by oils from the surface of the rice kernels. In brown rice, aged treatments produced lower rice weevil mortalities than did fresh treatments, and preconditioning of the dust by exposing it to milled or brown rice rendered it less effective against confused flour beetles when it was removed after 21 days and applied to rough rice.

Numerous investigators have evaluated diatomaceous earths and other inert dusts for use in pest control (Ebeling 1971). LaHue tested Perma-Guard® diatomaceous earth as a stored-product insect protectant and control measure in wheat (1965), corn (1966), and sorghum grain (1967). In each instance the material attained some degree of success. Little or no information, however, is available on its effectiveness in rice.

Recently, interest in diatomaceous earth has been revived, especially in regard to its possible use on rice as a protectant and control measure. Therefore, jar-scale testing was conducted to evaluate Perma-Guard diatomaceous earth as a treatment for rough, brown, and milled rice.

METHODS AND MATERIALS.—Perma-Guard is approved for use at a dosage of 7 lb/ton (3.5 g/kg) on rough rice. This and other dosages were evaluated for controlling rice weevils, *Sitophilus oryzae* (L.), and confused flour beetles, *Tribolium confusum* Jacquelin duVal. In the tests each dosage was applied to rice samples contained in 3.79-liter jars which were tumbled for 10 min to thoroughly mix the diatomaceous earth with the rice. The treated rice was then divided into 150-g samples. These were placed in 0.479-liter jars and 50 adult insects of a species were added to each jar so that the effectiveness of the treatments in these subsamples could be assessed. The same number of insects was added to untreated jars of rice (controls), to empty jars, and to treated jars containing no rice.

In Test 1, rice weevils and confused flour beetles were exposed for 21 days in rough, brown, and milled rice treated at dosages of 1.75, 3.50, 5.25, and 7.00 g/kg (3.5, 7.0, 10.5, and 14.0 lb/ton) and numbers of progeny and mortalities were compared with those of controls.

To determine whether longer exposure times would result in higher mortalities and whether the diatomaceous earth caused the observed mortalities directly or through feeding retardation, a 2nd test was conducted. In this test each species was exposed in jars containing treated or untreated brown rice or to the diatomaceous earth treatment alone. Insects were also held for the same time period in jars containing neither rice nor diatomaceous earth. Mortalities were observed at 3.5-day intervals.

In Test 3 effectiveness of diatomaceous earth was tested after it had been exposed to various rice samples. Samples of rough, brown, and milled rice were treated with diatomaceous earth at 3.5 g/kg and held at 27°C and 60% RH. After 21 days the diato-

[1] Coleoptera: Tenebrionidae.
[2] Coleoptera: Curculionidae.
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Table 1.—Percent mortality and percent progeny reduction, respectively, of insects exposed for 21 days in rough, brown, and milled rice treated with 4 levels of Perma-Guard diatomaceous earth in jar tests.[a]

Dosage g/kg	Rough rice	Milled rice	Brown rice
	Rice weevil		
1.75	100/100	91/64	87/14
3.50	100/100	100/64	99/87
5.25	100/100	100/80	100/93
7.00	100/100	100/100	100/99
	Confused flour beetle		
1.75	99/100	4/0	0/0
3.50	100/100	14/0	0/0
5.25	100/100	19/0	0/0
7.00	100/100	31/4	3/0

[a] Mortalities are corrected for control mortality in rough, milled, and brown rice, respectively (Abbott 1925).

maceous earth was sifted out and used to treat fresh samples of rough rice at the rate of 3.5 g/kg.

In Test 4 deterioration of diatomaceous earth treatments was evaluated by comparing rice weevil mortalities in fresh and aged (21 days) brown rice and rough rice treatments.

RESULTS AND DISCUSSION.—In Test 1 (Table 1) all dosages gave effective control for both the rice weevil and confused flour beetle in rough rice. Initial mortalities for rice weevils in all forms of rice were high, but progeny did develop in milled and brown rice at dosages below 7 g/kg. The material was ineffective against confused flour beetles in milled and brown rice.

Table 2 presents the results of Test 2. In the absence of food, the diatomaceous earth caused mortalities greater than those observed when insects were starved in empty jars. Also, the treatment killed confused flour beetles in brown rice at 7 g/kg, but mortality was not 100% even after 56 days.

The differences in mortalities, particularly for the confused flour beetle, that were observed in rough, brown, and milled rice are suggestive of the different levels of effectiveness against this insect in wheat, corn, and sorghum that were reported by LaHue (1965, 1966, 1967). As milled and brown rice have oily surfaces, it was suspected that the dust would become saturated with oil over a period of time. This would explain its ineffectiveness against confused flour beetles which require longer exposure to the unsaturated diatomaceous earth than do rice weevils for a high mortality to be achieved. In Test 3, mortalities in rough rice after 21 days exposure were 100% for fresh diatomaceous earth, 95% for diatomaceous earth sifted from rough rice, 7.4% for diatomaceous earth sifted from milled rice, and 2.5% for diatomaceous earth sifted from brown rice. It is assumed that the oil contained on the surface of milled and brown rice renders the treatment ineffective by satisfying the oil-sorptive capability of the dust. Acceptable rice weevil mortalities observed in brown and milled rice may have resulted because the rice weevil was more susceptible to the treatment and

Table 2.—Percent mortality of insects exposed to Perma-Guard diatomaceous earth in jars containing treated brown rice and in equivalently treated jars containing no rice as compared with mortalities in untreated jars of brown rice and untreated jars containing no rice.[a]

Exposure (days)	Treated brown rice	Untreated brown rice	Treated jars	Untreated jars
		Rice weevil[b]		
3.5	1	0	71	0
7.0	3	0	100	83
10.5	52	0	100	100
14.0	56	1	100	100
17.5	97	0	100	100
21.0	100	0	100	100
		Confused flour beetle[c]		
7.0	3	0	7	0
14.0	3	4	83	11
21.0	8	8	99	15
28.0	30	7	100	33
35.0	46	10	100	45
56.0	95	9	100	97

[a] Values for treated brown rice and treated jars are corrected for mortalities in untreated brown rice and in untreated jars containing no rice, respectively (Abbott 1925).
[b] Dosage of 3.5 g/kg of rice or 0.5 g/jar.
[c] Dosage of 7.0 g/kg of rice or 1.0 g/jar.

died before the diatomaceous earth became saturated with the rice oil.

In test 4, rice weevil mortalities were lower when treated brown rice (3.5 g/kg) was held for 21 days prior to introduction of the insects. In brown rice, fresh treatments yielded 57% mortality after 17 days exposure while 21-day-old treatments yielded 20% mortality after 17 days exposure. In rough rice the mortalities were 100% in both fresh and aged treatments after 7-day exposures.

The decrease in effectiveness with time might also result in rough rice although much longer time periods would be required as the rice hull effectively covers the oily surface of the brown and milled rice kernels. Oil sorption may cause the decrease in effectiveness through time that has been observed by other investigators with other seeds. The duration of effectiveness would be a factor of the amount of oil on the seed surface, the dosage, and the insect species.

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