206

Fumigation of Cereal Grains and Processed Products in Transport Vehicles with Phosphine from Detia Ex-B®[1,2]

JOHN H. SCHESSER[3,4]
U.S. Grain Marketing Research Center, Agric. Res. Serv., USDA, Manhattan, Kans. 66502

ABSTRACT

Bulk flour, bulk middlings, bagged flour, bulk brown rice, and a variety of packaged processed cereal products in boxcars, hopper cars, and a trailer van were fumigated with a powdered formulation of aluminum phosphide (Detia Ex-B®). Dosages were as close to 33 g PH_3/28.32 m^3 (1000 ft^3) as possible although variations in the volume of the vehicle precluded an exact dosage. All test insects, *Tribolium confusum* Jacquelin duVal, *Sitophilus oryzae* (L.), and *Cadra cautella* (Walker), were killed except when faulty construction of the vehicle resulted in low concentrations of phosphine.

Phosphine released from aluminum phosphide in Phostoxin® tablets or pellets has proved to be an effective and versatile fumigant since it was introduced in the mid-1950's (McGregor 1961). Another formulation called Detia Ex-B®, composed of a mixture of aluminum phosphide, aluminum stearate, and calcium oxide in small packets of special crepe paper is now available. Each packet of 34 g will release 11 g of phosphine gas (PH_3) when exposed to atmospheric moisture.

Ardley (1975), Cogburn (1974), and Anon. (1973) tested the efficiency of phosphine produced by Detia Ex-B. Such a technique was attempted by Schesser (1967) who used a grinder-blower to convert aluminum phosphide pellets to powder and then introduced the powder into railroad boxcars. Unfortunately, the rapid evolution of gas resulted in very high concentrations of phosphine that could be hazardous. This difficulty has been overcome with Detia Ex-B because aluminum stearate in the packets slows down the evolution of PH_3 so that flammable concentrations are not reached.

The tests reported here were made to determine whether Detia Ex-B would provide an effective way of fumigating railroad boxcars, railroad hopper cars, and trailer vans.

METHODS AND MATERIALS.—The 1st series of 3 tests was made at Kansas City, KS. Test 1 was in a boxcar loaded with bulk middlings, test 2 in a hopper car loaded with bulk flour, and test 3 in a boxcar loaded with bagged flour. The 2 boxcars were each treated with 12 packets (132 g PH_3) (suspended from nails in the walls); the hopper car was treated with 9 packets (99 g PH_3) that were tied to strings and tossed onto the surface of the flour (the strings were then used to recover the expended packets). Adult confused flour beetles, *Tribolium confusum* Jacquelin duVal, and 10 g of wheat containing larvae, pupae, and eggs of the rice weevil, *Sitophilus oryzae* (L.), from the laboratory colonies were caged and placed in the tips of the probes used to extract gas-air samples for analysis. The probes were inserted at the "A" and "B" ends of the cars (by Association of American Railroads terminology, A end = end opposite the brake wheel and B end = end with the brake wheel) and at the center (½ the distance between ends A and B), in the "overspace" (void area above the load) and at the top (6–8 in. below surface of load or beneath the upper layer in the case of boxes or bags) in the middle (½ distance from top of load to floor) and on the bottom (near the floor). Adult control insects were held under ambient temperature and humidity conditions and examined at the end of each test. Since all immature stages of the rice weevil were inside the wheat kernels, infested wheat controls were held until the adults had emerged.

[1] Received for publication Oct. 12, 1976.
[2] Mention of a proprietary product does not imply endorsement by the USDA.
[3] Research Entomologist.
[4] I thank Richard Bigler, Research Products Co., Salina, KS, for assistance and Loren Davidson, U.S. Grain Marketing Research Center, for analyzing air-gas samples.

Gas samples were analyzed by GLC in the laboratory at Manhattan, KS, from samples trapped in collection tubes. A hand operated pump that displaced one liter/stroke was used to evacuate the lines and withdraw the samples. The GLC method was a modification of the method described by Dumas (1964).

The 2nd series (7 tests) was conducted at Beaumont, TX. Tests 4, 6, 7, 9, and 10 were made in hopper cars loaded with brown rice. Tests 5 and 8 were made in a trailer-van partially loaded with packaged cereal products such as corn meal, pancake flour, and breakfast cereals. Adult confused flour beetles and larvae and pupae of the rice weevil in whole brown rice kernels (laboratory-reared) were used in all 7 tests. In addition, larvae of the almond moth, *Cadra cautella* (Walker), were used in test 5. Test insects were introduced as in the 1st series but gas analyses were made by Drager tube. In both series, test insects were exposed for the length of time indicated as gas concentration periods.

RESULTS AND DISCUSSION.—Table 1 shows concentrations of PH_3 recorded in the 1st series. The low concentrations at the bottom of the boxcar in test 1 were reflected by the 78.7% mortality of confused flour beetles at the A end bottom and the 21.2% at the B end bottom. Mortality was less than 1% among the control confused flour beetles. In tests 2 and 3, all flour beetles were killed. Average emergence was 11.9 rice weevils/sample in the controls. A total of 5 rice weevils emerged from tests 2 and 3 and none from test 1. No explanation for the complete kill of *S. oryzae* in test 1 is available at this time.

Table 1.—Concentration of PH_3 determined by GLC after fumigation with Detia Ex-B at a rate of 33 g/28.32m³ in Kansas City, KS.

Sample location	PH_3 (ppm) at indicated time posttreatment						
	4 h	8 h	1 day	2 days	3 days	4 days	5 days
Test 1—boxcar							
A end top	17	65	54	24	10	T[a]	T
Center overspace	146	194	136	58	34	T	T
B end bottom	T	T	T	T	T	T	T
B end middle	T	T	T	T	T	T	T
Test 2—hopper car							
A end bottom	449	340	282	306	235	85	51
Center middle	364	381	278	299	218	105	61
Center overspace	728	626	357	320	30	65	37
B end bottom	503	602	380	380	292	92	51
Test 3—boxcar							
A end top	102	92	44	24	T	T	T
Center overspace	54	44	27	T	T	T	T
Center middle	99	71	37	20	T	T	T
B end bottom	54	41	17	14	T	T	T

[a] T = trace (10 ppm is lowest level reliably measurable by the analytical procedure).

Table 2.—Concentrations of PH_3 determined by Drager tubes after fumigation with Detia Ex-B at a rate of 33 g/28.32 m³ in Beaumont, TX.

Sample location	PH_3 (ppm) at indicated time posttreatment						
	4 h	8 h	1 day	2 days	3 days	4 days	5 days
Test 4—hopper car							
Overspace	200	300	675	350			
Top	25	100	575	250			
Middle	T[a]	25	100	T			
Bottom	T	T	30	100			
Test 5—trailer van							
Overspace	50	175	200	75	100		
Top	50	125	200	75	100		
Middle	50	100	200	75	100		
Bottom	50	100	200	75	100		
Test 6—hopper car							
Overspace	100	175	125	25	T	T	T
Top	15	50	35	25	T	T	T
Middle	0	50	25	T	0	0	0
Bottom	0	0	T	25	0	0	0
Test 7—hopper car							
Overspace	300	775	1200	1000	575	400	300
Top	175	600	900	650	500	300	275
Middle	0	T	75	150	100	200	175
Bottom	0	0	50	30	40	50	100
Test 8—trailer van							
Overspace	35	60	50	50	100	50	100
Top	35	60	30	50	100	40	100
Middle	35	60	50	50	100	100	100
Bottom	35	40	50	50	100	100	100
Test 9—hopper car							
Overspace	125	500	775	1100	1100	1050	
Top	125	275	500	1100	975	1050	
Middle	150	75	100	275	300	475	
Bottom	125	100	100	275	300	500	
Test 10—hopper car							
Overspace	50	100	150	100	40	50	
Top	T	35	50	100	75	50	
Middle	T	T	25	50	50	50	
Bottom	T	T	T	50	25	50	

[a] T = trace (10 ppm is lowest level reliably measurable by the analytical procedure).

Table 2 shows concentrations of PH_3 produced in the 2nd series. In test 5, all *C. cautella* were killed; in the control, an average of 10 adults/sample emerged.

All other insects in all locations (overspace, top, middle, bottom at each end and center of the cars and trailer vans) in all tests were killed except that only 45% of *T. confusum* at the B end bottom of test 4 were killed and that some *S. oryzae* emerged as follows:

Test	Location	*S. oryzae* emergence
4	B end bottom	10
6	center middle	11
6	center bottom	18
6	B end bottom	12

In the controls, confused flour beetles had less than 1% mortality, and an average of 12.6 rice weevils/sample emerged.

Previous experience with Phostoxin made it possible to calculate with great accuracy the amount of Detia Ex-B required to obtain a kill of all test insects in properly sealed vehicles. When the gas concentrations failed to reach a lethal level, the test car was subsequently found to have structural faults, e.g., in test 1, low mortalities at the bottom were caused by a large crack in the floor of the car. The poor results at the middle and bottom locations in tests 4 and 6 were caused by a leaking door seal.

A superficial comparison of the results obtained in these tests with those obtained in previous tests with Phostoxin indicate that little or no difference exists in the amount or quality of PH_3 produced.

REFERENCES CITED

Anonymous. 1973. Detia-Ex-B experiment against storage insect pests on rice. Report of Ministry of Agriculture, Central Research Institute of Agriculture, Bogor, Indonesia. 19 pp.

Ardley, J. H. 1975. Comparison of two phosphine gas releasing products for fumigation of infested bulk wheat. Int. Pest Control 17:10, 12–13.

Cogburn, R. R. 1974. Detia Ex-B for phosphine fumigation of sacked milled rice. J. Econ. Entomol. 67: 436–8.

Dumas, T. 1964. Determination of phosphine in air by gas chromatography. Agric. Food Chem. 12: 257–8.

McGregor, H. E. 1961. Evaluation of phosphine gas as a fumigant for shelled yellow corn stored in concrete silo-type storage. Northwest. Miller 265: 38–9.

Schesser, J. H. 1967. Phosphine fumigation of processed cereal products in rail cars. Am. Miller Process. 95: 6 pp.

Reprinted from the
JOURNAL OF ECONOMIC ENTOMOLOGY