Penetration of Malathion in Stored Corn, Wheat, and Sorghum Grain[1]

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The rate at which malathion penetrated and degraded on wheat, corn, and sorghum was determined during a 6-month storage period. Analyses made 24 h after treatment to determine initial residue deposit showed that 85% or more of the total residue remained on the exterior of the kernels of all 3 grains. During the 1st month of storage, residues increased internally but decreased pronouncedly on kernel exteriors. During the remainder of the storage period, malathion residue disappeared from the exterior of the kernels more rapidly than from the interior.

Malathion, the principal insecticide used to treat stored grains, does not afford the same protection to sorghum grain (LaHue 1969) that it does to corn (LaHue 1966) and wheat (LaHue 1965). In cereal technology, the respiration of cleaned, undamaged grain is of minor importance to the degradation of malathion when the moisture content is under 14%. Total respiration of grain may arise from metabolism of the grain, micro-organisms, and insect infestation. Although many factors influence respiration because of metabolic processes in grain, moisture and temperature are the principal factors. Wheat has a critical moisture value of ca. 14.6%; corn, 14.2%; and sorghum grain, 14.3% (Bailey 1940).

In stored wheat, Strong and Sbur (1960) found that moisture contents of ca. 12 and 14% were the maximum safe and critical levels, respectively, for continued persistent biological effectiveness of malathion deposits and that effectiveness decreased as storage temperature increased.

We measured the amount of malathion that penetrated the kernels and determined the rate of disappearance from 14% moisture corn, wheat, and sorghum grain.

MATERIALS AND METHODS.—*Adjusting Moisture Content.*—All grains were conditioned to obtain the desired 14.0±0.2% moisture content. Neutral distilled water was added gradually over a 4-week period to increase 11.9% sorghum grain, 11.2% corn, and 10.7% wheat to the desired level. The grain was then sealed in 1-gal glass jars to equilibrate for 4 weeks at 26.7°C. Moisture content was determined with a Steinlite 512 RC moisture tester.

Malathion Treatment.—Premium grade malathion EC containing 57% malathion (5.0 lb Al/gal) was diluted with neutral distilled water to produce an emulsion containing 10 mg Al/ml for application of 1 ml/1000 g. Treatments as described by Kadoum and LaHue (1969) were used. After treatment, 100-g samples were placed in storage and maintained at 26.7°±1.1°C and 60% RH for aging. There were 5 replications.

Extraction and Clean-up Procedures.—Residues were extracted and cleaned for gas chromatographic analysis using a modification of Kadoum's procedure (1969). A 20-g sample was shaken vigorously with 100 ml of distilled acetone for 5 min to remove and determine the malathion from the grain surface. The extract was filtered and transferred with the aid of 50 ml of acetone wash to another 250-ml round-bottom flask. Extracts were concentrated to 2 or 3 ml under vacuum. Residues were transferred, using 10 ml hexane, to 250-ml separatory funnels containing 100 ml of water. Each funnel was shaken vigorously for 30 sec. After the layers separated, the lower or aqueous layer was drawn off and discarded. To analyze the upper hexane layer, it was partitioned with 80% acetonitrile in water. The internal malathion residue was determined on the 20-g sample by grinding and making a recovery with the aforementioned extraction procedure.

Gas Chromatographic Analysis.—An electron capture detector was used: column: 6-ft glass column of 3% DC-11 on 60-mesh silinized Gas Chrom P; carrier gas: nitrogen, 36 ml/min; temperature: column 200°C, detector cell 220°C, injector 240°C; volume injected: 4μl of the extract in hexane.

RESULTS AND DISCUSSION.—The rate of malathion degradation on and in sorghum, wheat, and corn during 6 months differed little (Table 1).

Table 1 shows the mean recovery of residue obtained 24 h after treatment was 96.8 for corn, 77.9 for wheat, and 82.7% for sorghum grain. Initially, penetration into the kernel was rapid. At all sampling times, malathion residue was greater on the exterior than on the interior of sorghum kernels. Residue was greater on the exterior than on the interior of wheat kernels sampled 24 h and at 1 month but was greater in the interior of those sampled at 3 and 6 months. Malathion residue was greater on the surface than on the inside of corn kernels sampled 24 h after application. However, all 3 grains showed more residue inside the kernels 1 month after treatment than they did at 24 h, 3, and 6 months. Results suggest that malathion penetrated the kernels most rapidly during the 1st month after treatment; thereafter, degradation rate masked the penetration rate. These data also suggest that residue loss from the surface resulted from penetration as well as from degradation of malathion.

The effect of the kernel's viability on the persistence of malathion residue was studied by Kadoum and LaHue (1972), who found that biological activity of the live sorghum enhanced malathion's breakdown rate. Rowlands and Horler (1967) examined the penetration of malathion on wheat during the 1st few days after it was applied and stated that most of the intact malathion was in the endosperm and that 3 organic solvents tested had no major effect on penetration. However, they concluded that moisture content apparently did not affect movement between the pericarp and endosperm and that malathion only penetrates into the germ at a moisture content of 14% or or lower. Kadoum and LaHue (1969) concluded that moisture content of the grain and storage temperatures affect malathion's rate of disappearance. However, moisture content is not the only important factor in determining the extent of degradation of malathion in stored grains. Increase in moisture content increased malathion's rate of breakdown (Kadoum and LaHue 1969) because water serves as a medium for biochemical

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Table 1.—Malathion residues on corn, wheat, and sorghum grain following 10 ppm applications.[a]

Interval after application	Residue recovery (ppm)		
	External	Internal	Total
	Corn		
24 h	8.23	1.45	9.68
1 month	2.00	2.62	4.62
3 months	1.27	1.62	2.89
6 months	.64	1.08	1.72
	Wheat		
24 h	6.73	1.06	7.79
1 month	1.86	1.65	3.51
3 months	.76	1.20	1.96
6 months	.38	.98	1.36
	Sorghum		
24 h	7.13	1.14	8.27
1 month	4.25	1.71	5.96
3 months	1.88	.93	2.81
6 months	.97	.62	1.59

[a] Stored at 26.7 ±1.1°C.

changes and enzymatic activity. The rate of penetration into and through the seed coat regulates the amount of insecticide reaching the different areas of metabolic activity in the grain.

Although partially depending on moisture content, penetration also depends on the polarity of the insecticide formulation used on the method of application (Rowlands and Horler 1967). Results of our study indicate that the type of grain did not affect the movement of malathion residue into the kernel and its rate of penetration could influence not only malathion's effectiveness as a grain protectant but also its degradation.

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