Effect of Hybrid, Moisture Content, Foreign Material, and Storage Temperature on the Degradation of Malathion Residue in Grain Sorghum[1,2]

AHMED M. KADOUM[3] and DELMON W. LA HUE[4]

ABSTRACT

Malathion was applied to grain sorghum from 6 hybrids at the rate of 1.0 pint of 57% emulsifiable concentrate per 1000 bushels. Little hybrid effect on malathion degradation was found during 12 months' storage at 80°F and 60% relative humidity. Grain moisture content and storage temperature significantly affected residue retention, but foreign material had no effect on the rate of malathion disappearance.

Production of grain sorghum has increased considerably during the past 5 years. About 80% of the yearly crop is sold through normal grain-marketing channels and is stored for many months in commercial warehousing facilities. Grain sorghum is readily attacked by many stored-product insect pests during storage. Malathion is the principal insecticide used in protective treatments on stored grains, but it does not afford the same protection to grain sorghum (La Hue 1967) that it does to corn (La Hue 1966) and wheat (La Hue 1965). Factors limiting the effectiveness of malathion have not been studied on grain sorghum. The effect of hybrid, moisture content, and storage temperature must be considered to make the most efficient use of the insecticide in its use as a protectant on grain sorghum.

In studies of grain moisture and storage temperature on the effectiveness of malathion on wheat, Strong and Sbur (1960) found that a moisture content of about 12% was the maximum safe level and 14% was the critical moisture level in wheat for persistent biologically effective malathion deposits, effectiveness decreasing with temperature increases. They showed the need for adjusting the dosage to compensate for adverse effects of moisture content and storage temperatures. Their conclusions agree with those of Lindgren et al. (1955) and Watters (1959) that the rate of malathion breakdown is greater with increased moisture content and at increased temperatures. Studies by Minett et al. (1968) showed the existence of a critical moisture level of approximately 11.8% for a storage temperature of 70°F and 11.6% for a temperature of 90°F. King et al. (1962) found grain sorghum moisture to be an important factor influencing malathion effectiveness against storage pests and that malathion residues do not persist on grain sorghum treated at moisture content above 14%. Studies by King et al. (1962) and La Hue's (1967) evaluation of malathion as a protectant against insects indicated the need for a detailed assessment of variables limiting the value of malathion as well as those showing malathion's effectiveness as a grain sorghum protectant.

This paper reports on studies of the influence of 6 Kansas-grown grain sorghum hybrids, foreign material, grain moisture content, and storage temperature on the degradation rate of malathion.

MATERIALS AND METHODS.—*Adjusting Moisture Content.*—The grain sorghum was conditioned to obtain the desired moisture content. Distilled water was added to increase moisture; to reduce moisture, the grain was dried at 105°–110°F in a forced-air laboratory dryer. Following each moisture adjustment, the sorghum was left to equilibrate for 2 weeks at 80°F. Adding water or drying was repeated until desired moisture was obtained, within limits of ±0.1% in each lot tested. Moisture content was determined with a Steinlite 512 RC moisture tester.

Malathion Treatment.—Malathion was applied at the rate of 1.0 pint of 57% premium grade EC/1000 bu. The concentrate was diluted with neutral distilled water to make an emulsion for 1-ml applications of 11.6 ppm technical malathion. Applications were made with a 1-ml volumetric pipette to the inside wall of a 1-gal, large-mouthed glass jar containing 1000 g of sorghum. The emulsion was discharged above the grain while the jars were turning at 33 rpm on a turn-table (Fig. 1). The jars were immediately sealed, shaken by hand for 30 sec, and rotated for a 15-min mixing period at 33 rpm on a mechanical tumbler. The emulsion, prepared immediately before use, was kept in a constant agitation at 80±1°F for application to 80°F grain. Immediately after treatment, the 1000-g samples were placed in storage rooms with the desired temperature and relative humidity.

Effect of Hybrids.—Six regionally-adapted hybrids of Kansas grain sorghum were conditioned to 12.5±0.1% moisture. 'Taylor-Evans 66,' 'Frontier 410E,' 'Dekalb C646,' 'Frontier 400C,' 'RS671,' and 'Dekalb F64' were

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[3] Assistant Professor, Department of Entomology, Kansas State University, Manhattan.

[4] Research Entomologist, Mid-West Grain Insects Investigations, USDA, Agr. Res. Serv., Manhattan, Kans.

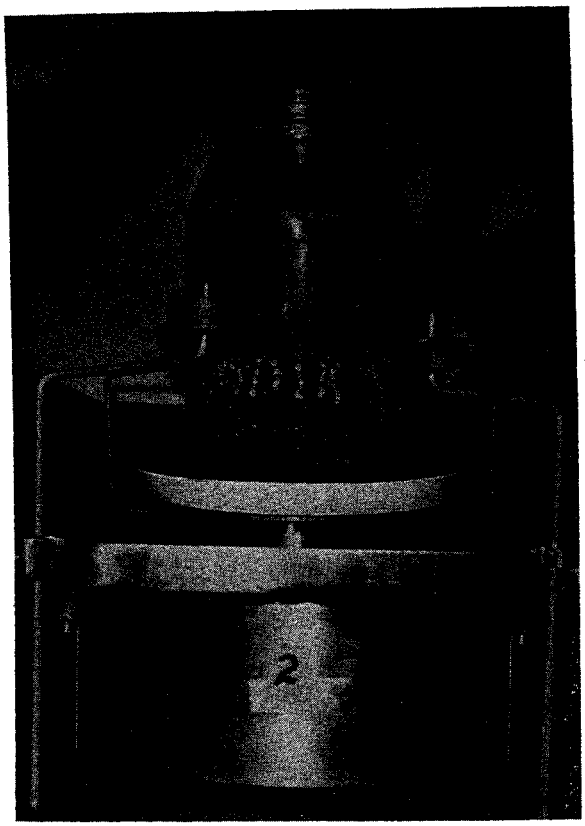

FIG. 1.—Applying 1 ml of malathion emulsion to 1000 g sorghum on a turntable.

the hybrids used. Individual lot samples of each hybrid were frozen at 0°F 24 hr after being treated and others after 1½, 3, 6, 9, and 12 months shelf storage, all at 80°±1°F and 60±5% RH.

Effect of Storage Temperature and Moisture Content.—Samples of 1 hybrid (Taylor-Evans 66) were conditioned to 7.0, 12.5, and 17.0% moisture. One lot of treated samples was stored at 45°F and another lot at 80°F. Malathion residue was determined 24 hr after treatment and after 3 and 6 months shelf storage.

Effect of Foreign Material.—Malathion was applied to 1 hybrid (Taylor-Evans 66) conditioned to 12.5% moisture containing the foreign material as harvested and with the foreign material removed. The harvested sorghum contained 3.78% foreign material (corn kernels, plant parts, weed seed, soil dusts, and insect parts). The 1000-g treated samples were stored in sealed 1-gal glass jars at 80±1°F and 60±5% RH. Malathion residue was determined 24 hr after treatment and after 3, 6, 9, and 12 months shelf storage.

Extraction and Clean-up Procedures.—Malathion residues were extracted and cleaned for gas chromatographic analysis using a modification of Kadoum's methods (1968, 1969). A 20-g sample was blended with 100 ml distilled acetone in a covered Sorval omnimixer at top speed for 5 min. The acetone extract was filtered and transferred with the aid of 50 ml of acetone wash to a 250-ml round-bottom flask. The filtered acetone extract was concentrated to 2 to 3 ml under vacuum. The residue was transferred, using 10 ml hexane, to a 250-ml separatory funnel containing 100 ml of water. The funnel was shaken vigorously for 30 sec. After the 2 layers separated, the lower or aqueous layer was drawn off and discarded. The upper hexane layer was partitioned with 80% acetonitrile in water for analysis (Kadoum 1968).

Gas Chromatographic Analysis.—An electron-capture detector was used to analyze malathion under the following operating conditions: 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°F; volume injected: 4 μliter of the extract in hexane.

RESULTS AND DISCUSSION.—The rate of malathion degradation on the 6 hybrids is graphically shown in Fig. 2. Though apparent differences were found in malathion retention by 2 hybrids at the 6-month period, the overall uniform drop for all hybrids throughout the test indicates little hybrid effect on malathion degradation.

Foreign material had no effect on the rate of disappearance of malathion (Fig. 3).

Rates of malathion residue breakdown were determined for grain sorghum at 3 widely separated levels of moisture at 2 storage temperatures. The rate of breakdown of malathion residues was greater with increased moisture content and at higher temperatures (Fig. 4), agreeing with Minett et al. (1968) who used a colorimetric analysis procedure, and Strong and Sbur (1960) who used insect bioassays. King et al. (1962) concluded that effective malathion residues do not persist on grain sorghum treated at moisture contents above 14%. It thus appears that for grain

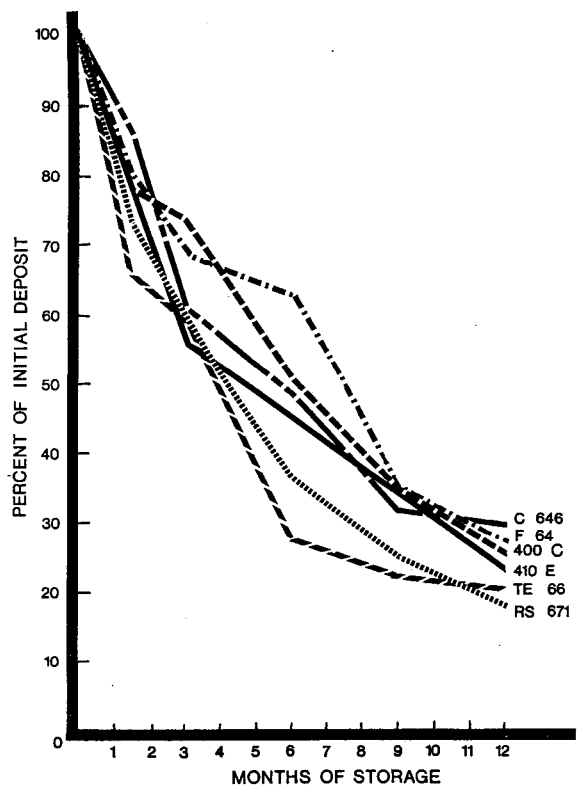

FIG. 2.—Malathion residue recovery from 6 hybrids of grain sorghum during 12 months storage. Percent recovery based on initial deposit determined 24 hr after application.

sorghum stored at a constant temperature, there was possibly a critical moisture level above which the breakdown of malathion residues rapidly increased. Other studies using gas liquid chromatography indicate a critical moisture level of grain that varies according to storage temperature. Minett et al. (1968) concluded that critical moisture levels are approximately 11.8% for a storage temperature of 70°F and 11.6% for 90°F in wheat studies. Strong and Sbur (1960) concluded that a moisture content of 12% appeared the maximum safe level and 14% the critical level for persistent biologically effective malathion deposits.

Accordingly, we found grain sorghum with a 12.5% moisture content contained 30.6% and 78.0% of the initial deposits of malathion after 6 months' storage at 80°F and 45°F, respectively.

Our study has practical application in storage and market distribution of treated grain, for predicting the malathion level in stored sorghum so dosage can be biologically effective (La Hue 1967, 1969) for extended storage periods.

CONCLUSIONS.—Moisture content and storage temperature determine effectiveness and persistence of malathion residue in grain sorghum. Results showed that with increased storage temperatures, malathion degradation increases with grain sorghum at relatively high moisture content. It appears grain sorghum should not be stored for extended periods at 12.5% grain moisture, a critical level for malathion degradation at 80°F. Hybrid differences and foreign material did not affect the disappearance rate of the malathion residues.

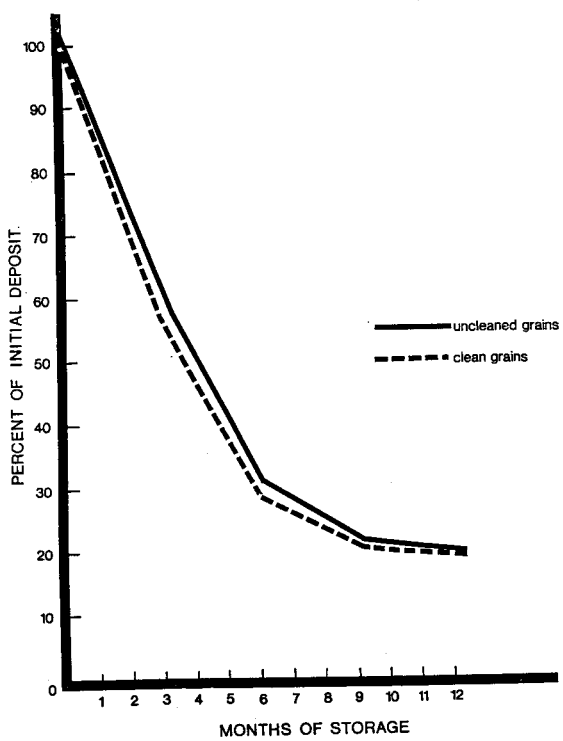

FIG. 3.—Malathion recovery from cleaned and uncleaned sorghum grain. Percent recovery based on initial deposit determined 24 hr after application.

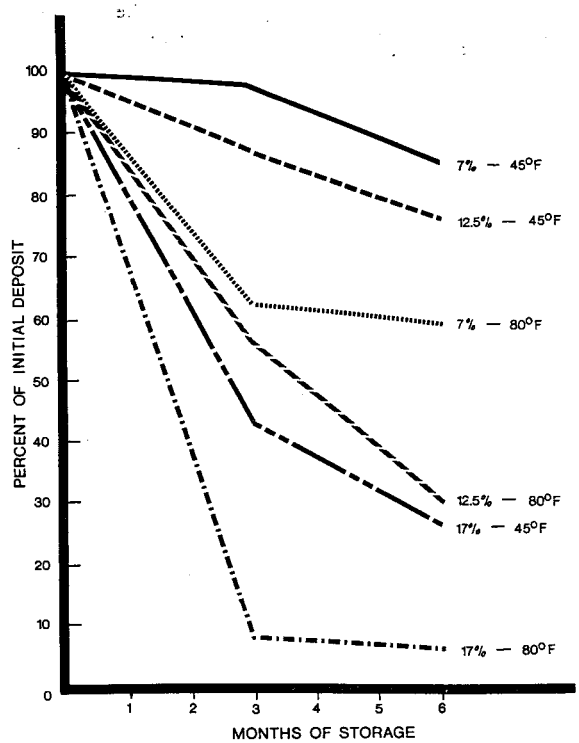

FIG. 4.—Malathion residue recovery from sorghum grain of 3 moisture contents and 2 storage temperatures. Percent recovery based on initial deposit determined 24 hr after application.

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