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Degradation Rates of Technical Carbofuran and a Granular Formulation in Four Soils with Known Insecticide Use History

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Carbofuran is a systemic insecticide widely used to control corn rootworms, Diabrotica spp. Based on corn root ratings and yield increases, carbofuran has been shown to perform effectively under field conditions in Nebraska (MAYO et al. 1977), Illinois (SECHRIEST et al. 1977), and South Dakota. Failure of carbofuran to control corn rootworm larvae was observed in a portion of a field near Waseca, Minnesota. This portion had a history of several years of carbofuran application. The present study was designed to determine carbofuran degradation in soils with known insecticide performance and use history. In addition, we compared degradation rates of a granular formulation with technical grade carbofuran under similar conditions and soil.

MATERIALS AND METHODS

SOIL SAMPLES: Soils from 4 different field locations at the University of Minnesota Experiment Station, Waseca, Minnesota, were selected. Ten 1-lb samples were collected from each location and pooled. The first location (S-1) was from a field plot that had been treated with carbofuran for several years and carbofuran perfomed poorly in 1977 field insecticide trials as based on root damage ratings. The second (S-2) was from adjacent untreated rows. Sample (S-3) was from a location that had no previous history of insecticide application and carbofuran performance was considered satisfactory, while sample S-4 was obtained from the adjacent untreated rows. These soils, classified as silty clay loams, had the following analysis: 4.6% organic matter, 46.4% sand, 30.8% silt, 22.8% clay, and pH of 6.5. Moisture content of the samples ranged from 19.8% to 21.5%.

INCUBATION OF CARBOFURAN: Thirty subsamples of 50 g and 15 subsamples of 10 g of each soil (average moisture 20%) were weighed from each collection site. Each 50 g subsample was fortified to contain 40 ppm AI using 10% granular carbofuran while the 10 g subsamples were fortified to contain 8 ppm AI using technical grade carbofuran. All samples were then air dried for 2 h at room temperature to allow equilibration and evaporation of acetone. The flasks were then sealed with rubber stoppers and incubated at 22 $\pm$ 2°C. All samples were opened every day for 15 min. A moisture level of 20 $\pm$ 2% was maintained in all the soil subsamples by addition of distilled water every third day.

RESIDUE DETERMINATION: Three subsamples of each of the soils were extracted at various time intervals after incubation of

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carbofuran. Untreated soil samples were also extracted at each sampling day, and they indicated no residues of carbofuran due to previous field application. Extraction and cleanup of carbofuran formulation and technical material was accomplished by the acid hydrolysis method of COOK (1973). The extraction efficiency of the carbofuran ranged from 86-92% when fortified with 20, 50, or 100 ppm as a granular formulation or the technical material.

ANALYSIS: Carbofuran residues were assayed with a gas chromatograph equipped with Nitrogen-Phosphorus flame ionization detector and a glass column (1.8 m x 3 mm OD) packed with 5% DC-200 on 100/120 mesh Chromosorb W-HP. GLC conditions were the following: temperature (°C), column oven 165, and inlet 200; and the gas flow rates, carrier gas (helium 30 mL/min). All extracts were fortified with 10 µg/mL azobenzene which was used as an internal standard. Under these GLC conditions 20 ng of carbofuran/µL in acetone produced a recorder response of 30-40%. Retention times for azobenzene and carbofuran were respectively 3.31 ± .01 and 4.93 ± .02 min. Results were analyzed by two way analysis of variance, t-test, and linear regression.

RESULTS AND DISCUSSION

Residues of technical and granular carbofuran are presented in Tables 1 and 2. These residues are the means from 3 soil subsamples for each incubation period and based on dry soil weights. Our results show (Tables 1 and 2) significant differences ($P<0.01$) in soil degradation rates comparing the 10% granular formulation and technical carbofuran. More than 50% of the technical insecticide was lost within 7 days after incubation in soil samples S-1, S-2, and S-3 while 14 days were required for 50% disappearance from sample S-4. After 21 days of incubation, only 15, 19, 18, and 21% of the applied technical carbofuran could be recovered respectively from S-1, S-2, S-3, and S-4 soil samples. However, the granular formulation of carbofuran dissipated from the soil samples at a much slower rate. At the conclusion of this experiment (35 days after incubation) 75, 63, 70, and 65% of the applied granular dosages were recovered in S-1, S-2, S-3, and S-4 soil samples respectively.

TABLE 1. Degradation of technical carbofuran under laboratory conditions in 4 soil samples from Waseca, Minnesota.

Days after application	PPM residue dry soil weight ± standard deviation			
	S-1	S-2	S-3	S-4
0	9.5±0.5	9.6±0.4	9.0±0.8	9.0±0.5
7	4.5±0.3	4.2±0.3	3.7±0.1	5.9±0.3
14	4.0±0.3	3.8±0.2	3.0±0.1	4.5±0.3
21	1.5±0.1	1.9±0.1	1.5±0.3	2.0±0.2

TABLE 2. Degradation of 10% granular carbofuran under laboratory conditions in 4 soil samples from Waseca, Minnesota.

Days after application	PPM residue dry soil weight ± standard deviation			
	S-1	S-2	S-3	S-4
0	43.0±2.0	44.0±1.0	44.0±2.0	43.0±2.0
7	39.0±0.4	33.0±1.0	40.4±3.0	39.0±3.0
14	34.0±2.5	30.0±1.5	31.5±1.0	42.0±4.0
21	39.0±1.0	33.0±2.0	35.5±1.3	33.0±3.0
28	34.0±3.0	31.0±1.0	34.0±3.5	33.0±2.0
35	32.0±3.0	27.0±2.0	31.0±4.0	28.0±2.0

A two way analysis of variance was used to compare the dissipation rates of carbofuran technical and granular formulation from the 4 soil sample sites. The analysis showed that there were no differences in the residue levels of carbofuran due to locations; however, significant differences ($P<0.01$) were indicated in residue levels due to time of incubation. Based on the regression analysis of the data, the technical carbofuran had a calculated half-life of 11-13 days, whereas, the granular formulation had a half-life of 60-75 days in soil samples from the 4 different locations.

This study indicates that carbofuran was equally persistent in the soil samples collected from 4 different locations. The apparent failure to control a corn rootworm infestation at locations S-1 in 1977 was probably due to reasons other than its rapid degradation. If microbial activity (VENKATESWARLU et al. 1977) was responsible for rapid degradation in the S-1 site in 1977, this same activity should have occurred in this controlled laboratory study. Carbofuran may be subjected to rapid hydrolysis in alkaline soils, but is moderately persistent at a pH of 6.8-6.4 (GETZIN 1973). The soil pH in this study was 6.5 and did not vary among locations.

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