Degradation of Disulfoton and Phorate in Soil Influenced by Environmental Factors and Soil Type

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Systemic insecticides applied to the soil for the control of insect pests on the aerial parts of plants are subject to degradation in the soil before they are taken up by the plant. Their rate of degradation in the soil is influenced by soil type (1,4,5), moisture content (3), soil temperature (7), organic matter content (1,4), and microbial activity (3). Some factors have been shown to be interrelated (3) and some effects undoubtedly result from causes not related directly to the parameter being measured in an experiment.

Disulfoton and phorate are systemic organophosphorus insecticides which have shown great promise in soil applications, particularly for the control of sucking insects (8). In an earlier study the residues of disulfoton and phorate which appeared in the aerial parts of spinach grown in treated soil were investigated (8). The residues of these materials in the soil were then determined to ascertain the effect of winter temperatures on the disappearance and metabolism of each; in addition, two different soil types were involved in the summer versus the winter plantings.

Experimental

Disulfoton and phorate (both 10% granular formulations) at 2 lb actual per acre were applied broadcast to replicate plots on October 13, 1964, and disked in just before seeding with winter spinach (Old Dominion variety) on the Vegetable Research Farm of the University of Maryland at Salisbury. Subsequent applications of the same insecticides at the same rate were made to additional replicate plots November 13, 1964, December 22, 1964, and March 12, 1965. One application of insecticide on a given date to plots replicated twice constituted a treatment; no plots were retreated. The post-planting applications were broadcast and lightly worked in between rows with a hand cultivator. The field was watered after treatments.

To compare residues of both insecticides in both winter and summer crops, plots of Old Dominion variety spinach were planted June 18, 1964, on the Plant Research Farm of the University of Maryland near Fairland. Replicate plots were treated with 10% granular formulations of disulfoton and phorate each at 2 and 4 lb per acre. The first treatments were applied broadcast and disked in immediately before seeding. Disulfoton was broadcast on

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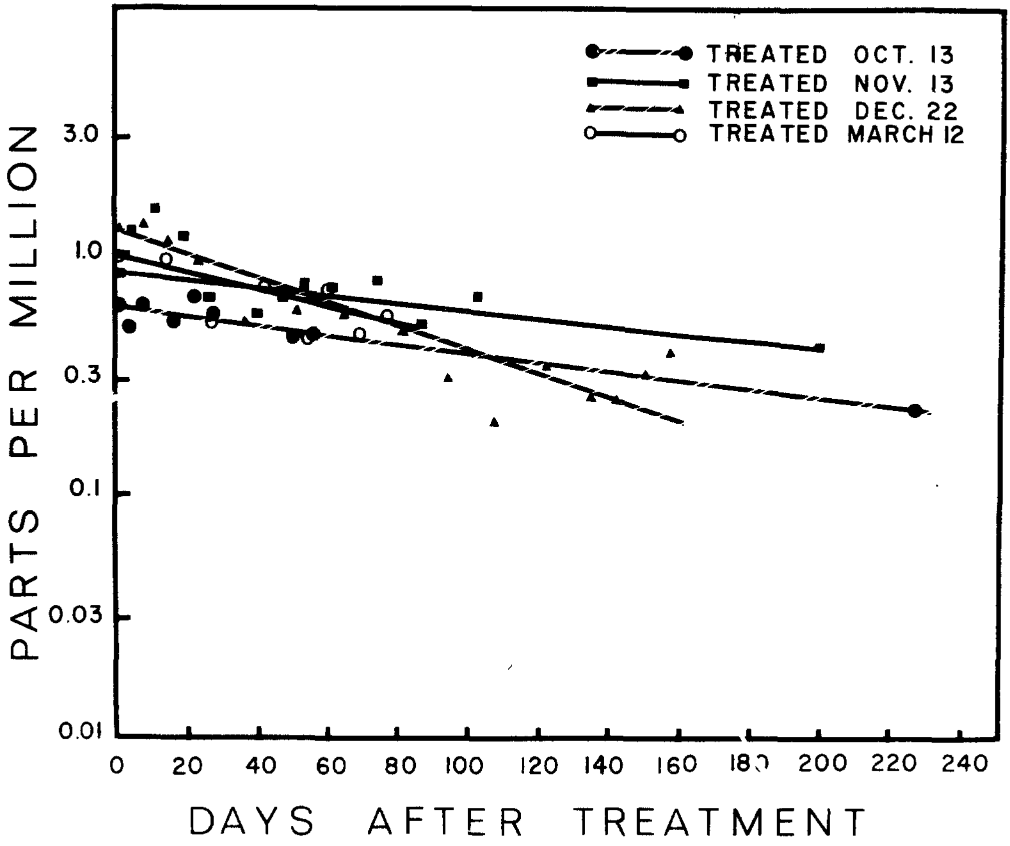

Figure 1. Disulfoton residues in soil treated at 2 lb actual per acre at intervals during the winter.

additional plots July 21, when the plants were approximately 2 inches high, and lightly harrowed in.

Each plot was sampled in duplicate by taking 50 cores across the 4-foot width of the plot with a 1-inch soil auger to a depth of 4 inches. The 50 cores were combined and mixed thoroughly before an aliquot of 200 g was taken for analysis. Analysis of samples was accomplished by a total phosphorus procedure as described earlier (8). The compounds analyzed by this procedure include the parent compounds and the metabolites resulting from oxidation of the phosphorus and the mercapto sulfur. Recoveries of added disulfoton or phorate ranged from 85-92%. In order to corroborate the results obtained by the colorimetric procedure, gas chromatographic analysis using a sodium thermionic detector was conducted on most of the samples.

To characterize the residues present in the soil, each sample was subjected to thin-layer chromatography on silica gel G as described earlier (2,8).

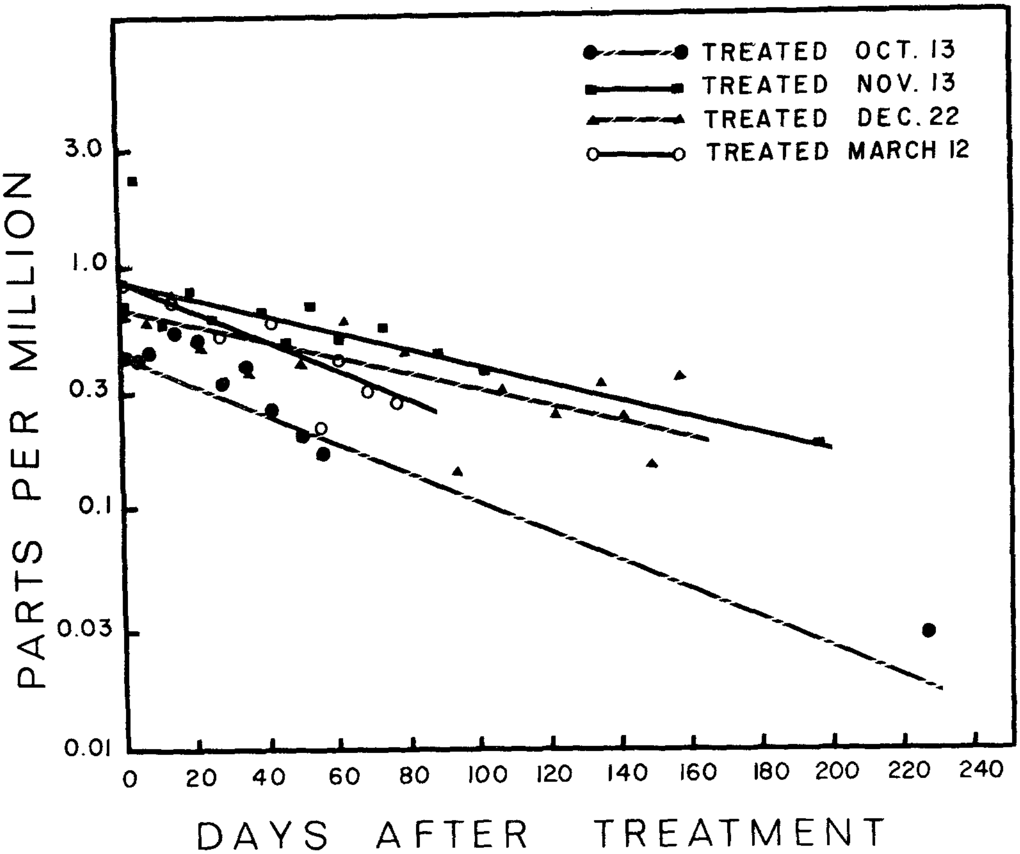

Figure 2. Phorate residues in soil treated at 2 lb actual per acre at intervals during the winter.

Results and Discussion

Generally speaking, the residues of disulfoton were slightly higher than those of phorate in the soil treated during the winter. The differences in the rates of degradation of the two insecticides however, did not seem to be closely related to the temperature differences during the sampling periods from October through April. The differences between disulfoton and phorate residues in the spinach grown on the treated plots were greater than in the soil itself (8). Curves for disulfoton and phorate disappearance from the soil are given in Figures 1 and 2. In the soil treated during the summer, there was almost no degradation of disulfoton within 60 days, and only slight decomposition of phorate (Table I). It appears that soil type has a greater influence on the rate of decomposition of these insecticides in soils than the temperature, since both insecticides used in these studies were more rapidly degraded in the winter than in the summer, contrary to what one would expect based on only temperature effects. The winter treatments were made to Evesboro loamy sand, while the summer ones were applied to a heavier soil, Chillum silt loam. Other workers have obtained similar results with several organophosphorus insecticides. Beynon and co-workers (1) showed that diethyl 1-(2,4-dichlorophenyl)-2-chlorovinyl phosphate was most persistent in peat and least persistent in sandy loam. Getsin and Chapman (4,5) obtained the same result with phosdrin and concluded that organic matter content was primarily responsible for insecticide binding to soil. These results in soil contrast with the findings in the spinach foliage where both insecticides were degraded more rapidly in the summer than in the winter (8).

TABLE 1

Disulfoton and Phorate Residues in Soil Treated During the Summer

Days After Application	Disulfoton, ppm				Phorate, ppm	
	2 lb/A	4 lb/A	2 lb/A[a]	4 lb/A[a]	2 lb/A	4 lb/A
0	0.92	1.44	-	-	1.34	1.44
3	-	-	0.83	1.20	-	-
10	-	-	1.31	2.06	-	-
22	0.74	1.66	-	-	1.10	1.02
27	-	-	0.80	1.26	-	-
41	-	-	1.11	1.74	-	-
43	0.99	1.42	-	-	1.07	1.32
60	1.33	1.08	-	-	0.77	0.89

[a] Application after plants were 2 in high in late summer

Thin-layer chromatography of the soil extracts revealed that the identities of metabolites in the soil were very similar to those isolated from foliage samples. Large amounts of the sulfones of both insecticides and their oxygen analogs were present. Only minute amounts of the oxygen analogs and the sulfoxides of the parent compounds and their oxygen analogs were detected. In the early samples, very small amounts of the parent compounds were found, but these were apparently quickly converted to the sulfones in later samples. Larger quantities of the parent compounds were found in winter samples than in the summer ones, indicating that metabolism of these compounds is accelerated by higher temperatures, although this is probably due to increased microbial activity, rather than to the higher temperature itself.

Part of the cause of the rather long persistence of disulfoton and phorate in soils is undoubtedly their very low mobility in soil. Harris (6) reports mobilities of 1.1-1.2 for both materials, indicating that there is very little possibility of either material percolating below the plow level of the soil. Furthermore, the low temperatures during the winter would tend to impede the decomposition of disulfoton and phorate (7). However, the very slow decomposition of these materials in the Chillum silt loam during the summer remains to be explained.

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