Insecticide-induced Responses in an Old Field Ecosystem: Persistence of Diazinon in the Soil[1]

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To obtain insight into the problem of soil contamination by pesticides, a long-range project has been initiated to investigate insecticide-induced responses in an abandoned field. Old field ecosystems are comparatively simple and allow more thorough considerations of the major biotic components than are possible for most other natural ecosystems.

Although typical pesticide treatments of cropped fields consist of multiple applications of several chemicals, a single application of a relatively short-lived insecticide was used in this study. It was felt that a moderately heavy dose rate of such an insecticide would induce most ecological interactions that might occur in a contaminated ecosystem. At the same time, a short residue might permit the system to recover and equilibrate within a reasonable amount of time.

The old field under investigation comprises an area of 14 acres selected from a 40-acre corn field on the New Jersey piedmont.

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1 This research was supported in part by National Science Foundation Grant GB 3343.
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Bulletin of Environmental Contamination & Toxicology,
Vol. 2, No. 2, 1967, published by Springer-Verlag New York Inc.

The soil type is Reaville Shaley Loam, derived from Brunswick shale bedrock. Treatment consisted of 14 lbs. of actual Diazinon per acre, as a 50% wettable powder, disced into the soil to a depth of 2 inches. Half the field received the insecticide, the remaining 17 acres was only disced and is serving as a control. Treatment and abandonment of the field occurred on May 6, 1966.

Ecological parameters in use to evaluate the effect of Diazinon on the old field ecosystem are density, diversity, and net primary productivity of herbaceous species; density and diversity of herb stratum insects; density of soil microarthropods, and the disappearance rate of soil organic detritus.

A necessary consideration in a study of this nature is the persistence of the chemical contaminant. To provide these data soil samples were analyzed for Diazinon by gas chromatography. The following is a report of the persistence of Diazinon in the clay loam soil. Ecological effects have been so pronounced that one growing season has been insufficient time for the treated area to equilibrate with the control. Generalized ecological responses will, however, be detailed briefly.

Procedure

Although 7 acres were available in both the treated and the control areas, all sampling thus far has been confined to a 200 m x 30 m plot in each area. Soil samples were collected from the experimental plot at depths of 0-2 inches and 4-6 inches at pre-treatment, immediately following discing, and at seven additional intervals up to 81 days. The control plot was sampled at 0-2 inch depth on each of the sampling dates.

The soil samples were each composited from four 1-quart portions collected at random points in the plots. At least two individual composites were made from independent sets of four 1-quart samples in the case of the samples of the upper 2 inches of soil from the treated plot.

Eight hundred grams were weighed from each composite and extracted at 1:1 ratio with petroleum ether for gas chromatographic analysis. While numerous methods have been reported for Diazinon analysis (1-7) the gas chromatographic method described here was considered most suitable for monitoring the Diazinon in the soil, and for future work in determining possible residues in plants and animals involved in the ecological system.

A Mikro-Tek MT 220 gas chromatograph equipped with nickel (Ni^{63}) electron capture detector was used with the following column and conditions:

column: 4 ft. glass, 1/4 inch O. D., packed with 5% DC 200 on Chromasorb W (80-100) HMDS treated

injection: 5 microliters on column

carrier gas: 95% argon - 5% methane at 60 ml/mm flow rate

temperature: inlet 225°C, column 170°C, detector 250°C

power supply: pulse rate 240 microseconds, width 3 microseconds

cell voltage: 30 volts

elution time: 4 1/2 min/0.9 inches

attenuation: 10 x 128

recorder: 0.2 inch/min., 1 mv. range

Results and Discussion

The analytical results are recorded in Table 1.

TABLE 1.

Diazinon Residues in Soil

Days After Application	Control	Residue (ppm) Treated (0-2)	Treated (4-6)
Pre-application		0.00 0.00	
Zero (immediately after application	0.00 0.00	127 194 192 150 148 120	0.46
5	0.00	129 130	0.10
13	0.00	45 55	0.25 0.15
26	0.00	10.67 6.47 8.70	0.10
40	0.00	4.27 4.70 4.47	0.25
54	0.00	2.50 3.67 2.70	0.00
68	0.00	0.00 0.00 0.00	0.00
81	0.00	0.00 0.00 0.00	0.00

Pretreatment samples showed no Diazinon, and none of the control plot samples appeared to have been contaminated with the insecticide. Calculation of the initial amount of Diazinon residue in the upper 2 inches of treated soil shows an average concentration of 14 pounds per acre, indicating uniform application and good recovery.

Very low levels of Diazinon residue were found in the 4 to 6-inch soil fraction in samples up to 40 days after treatment. The fact that 3.5 inches of rain fell during the first 13 days suggests that very little downward leaching can be expected, and that the direct effects of the insecticide will be near the surface.

The rapid disappearance of Diazinon from the soil (Table 1) suggests that any direct ecological effects of this chemical were confined to a relatively short time period. With such a short-lived residue present in the soil at abandonment, it might be expected that any ecological effects in an old field ecosystem would be of short duration and perhaps of small magnitude. This, however, has not been true in the case reported here. For instance, densities of soil microarthropods remained depressed into the fall of 1966, despite the fact that detectable levels of Diazinon were absent from the soil after June. The adverse effects of Diazinon on soil microarthropods has been demonstrated previously (8).

Effects on population structure and dynamics of herb stratum insects also were perpetuated throughout the growing season. Initially, total insect density in the treated area was depressed, but rapid resurgence of some species resulted in a significantly greater total density than in the control by early fall. Resurgence of pest species apparently is one of the problems resulting from the use of insecticides (9).

Perhaps the most significant responses on the treated area have concerned the dynamics of the vegetation invading the abandoned field. Species diversity and density have increased on the treated area, and associated with these responses have been decreased shoot production and increased root production. Similar responses have been demonstrated in some turfgrasses under intense maintenance and are thought to be insecticide-induced (10).

These results suggest that at least some kinds of insecticide residues present in soil can be expected to influence the subsequent nature of an old field ecosystem. The recovery rate of the contaminated ecosystem under investigation here apparently is not dependent solely upon the persistence of the pollutant, for even after disappearance of the Diazinon, initial effects were so pronounced that the ecosystem remained changed throughout one entire growing season. Thus, the indirect effects of soil treatment may be of sufficient magnitude to perpetuate changes in an ecosystem even after the contaminant has disappeared. These may of course be due in some cases to degradation products, though none were detected in this study.

The ultimate effects of the above initial responses on the successional pattern and climax community of the treated area presently are not known. Whether the treated old field ecosystem will eventually equilibrate with the control is the subject of continuing research.

References

1. R. Suter, R. Delley and R. Meyer, Z. Anal. Chem., 147, 173-184, (1955).

2. R. C. Blinn and F. A. Gunther, J. Agr. & Food Chem. 3, 10, 13, 16 (1955).

3. W. P. McKinley and S. I. Read, J. Assoc. Offic. Agr. Chemists, 45, 467-73, (1962).

4. M. E. Getz, J. Assoc. Offic. Agr. Chemists 45, 393-6, (1962).

5. H. F. MacRae and W. P. McKinley, J. Agr. & Food Chem. 11, 174-8, (1963).

6. H. P. Burchfield et al., J. Gas Chromatog. 3(1), 28-34 (1965).

7. R. W. Storherr et al., J. Assoc. Offic. Agr. Chemists 47(6), 1087-93 (1964).

8. C. A. Edwards, in G. T. Goodman and R. W. Edwards (ed.), Ecology and the Industrial Society, 239-61 (1965), Blackwell Sci. Publ., Oxford.

9. Rudd, R. L., Pesticides and the Living Landscape, 320 (1964), Univ. of Wiscon. Press, Madison.

10. H. T. Streu and L. M. Vasvary, Bull. New Jersey Acad. Sci., 11, 17 (1966).