Absorption and Translocation of Dieldrin by Forage Crops

WILLIS B. WHEELER, DONALD E. H. FREAR, RALPH O. MUMMA, ROBERT H. HAMILTON, AND RONALD C. COTNER

Quantitative relationships have been established among various levels of dieldrin in sand and in soil, and the concentrations found in the aerial portion of wheat, corn, orchard grass, and alfalfa grown in these substrates under controlled environmental conditions. Plants grown in sand contained levels of dieldrin two to six times higher than plants grown in soil. A second cutting of the same wheat plants revealed a higher accumulation of the insecticide than the first cutting. Finally, the general distribution of dieldrin within young wheat plants was determined by chemical analysis. Plants used for forage were capable of absorbing and translocating dieldrin from the substrates in which they were grown. The fact that there was a far greater uptake from sand than from soil may be of practical significance in the applications of these pesticides to different soil types.

The chlorinated hydrocarbon insecticides have been used extensively for the control of insect pests. These chemicals are known to persist in the soil even for several years after application (*2*, *6*, *7*). It has been demonstrated that some plant species are able to absorb and translocate these chemicals. Most of the investigations have been conducted using edible root and tuber crops; however, the presence of detectable quantities of internal chlorinated insecticides has been reported in cereal grain and above-ground fruits (*1*, *5*, *9*, *10*). Recently there has been a growing interest in the possibility that forage crops absorb and translocate these chemicals. It has been suggested that such internal residues might be partially responsible for the presence of insecticides in the milk of dairy cows fed forage which had not been treated with these compounds.

Wheat straw and grain have been shown to contain appreciable quantities of dieldrin (1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8*a*-octahydro-1,4-*endo-exo*-5,8-dimethanonaphthalene) when taken from plants grown in soil containing abnormally high (20 p.p.m.) concentrations of this compound (*9*). Only relatively small dieldrin residues, however, have been detected in alfalfa (*8*, *12*) and corn (*12*) grown in soils treated with recommended amounts of this chemical. Conversely, King, Clark, and Hamken (*3*) have reported relatively high (up to 1.52 p.p.m. dry basis) heptachlor epoxide (1,4,5,6,7,8,8 - heptachloro - 2,3 - epoxy - 3*a*,4,7,7*a*-tetrahydro-4,7-methanoindene) levels in alfalfa grown in soil treated with heptachlor at a rate of 1 pound per acre.

Many factors may affect the level of root-absorbed insecticides found within a plant: the type of growing medium, the levels of insecticide in the substrate, the specific insecticide, the plant species, the age of the plant, and several other environmental conditions including light, water, and temperature.

Pesticide Research Laboratory, Departments of Entomology, Biochemistry, and Botany, The Pennsylvania State University, University Park, Pa.

This paper provides data concerning the ability of alfalfa, wheat, corn, and orchard grass to absorb and translocate dieldrin from two substrates. Data are presented on the quantitative relationship between the levels of insecticide found within the aerial portions of four species and the levels of the compound in the growing media. Further, the localization of dieldrin within specific plant parts and variations of insecticide levels found in second cuttings made from the same is discussed.

Experimental

Corn, wheat, alfalfa, and orchard grass were grown in sand and in soil containing labeled and unlabeled dieldrin to determine whether or not these plants were capable of absorbing and translocating this insecticide. The data presented represent approximately 600 analyses.

The details of the plant culture, plant species, extraction, and cleanup procedures as well as analytical techniques have been described (*11*).

Results and Discussion

The corn plant in Figure 1 (left) was grown in sand containing 15 p.p.m. of ^{36}Cl-dieldrin. A radioautogram of the same plant (right) reveals distribution of the label throughout the plant and a relatively large amount of radioactivity associated with the roots. A subsequent extraction and analysis confirmed the presence of radioactive dieldrin. The other three species also absorbed and translocated ^{36}Cl-dieldrin. Radioautograms, similar to the one shown for corn (Figure 1), were also obtained. No translocation of radioactivity could ever be detected by radioautography when labeled dieldrin was applied to the plant surfaces.

One of the primary questions which arose early in this study was whether the dieldrin residues were inside the plant or were merely surface contaminations caused

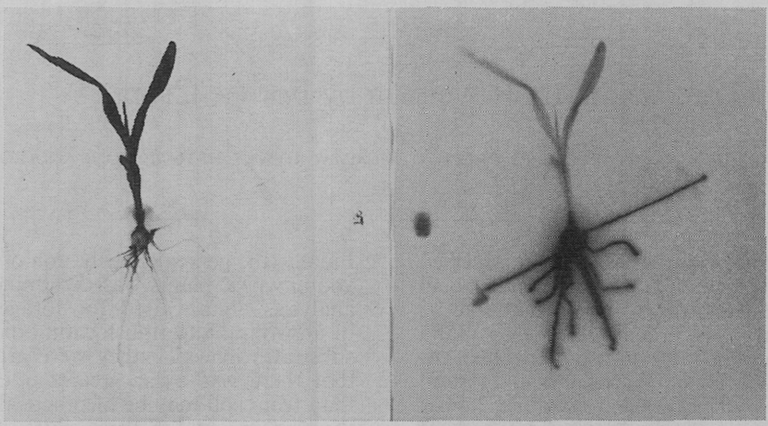

Figure 1. Radioautogram of a corn plant grown in sand containing 15 p.p.m. ^{36}Cl-dieldrin

Left. Plant
Right. Radioautogram

by volatilization of the chemical from the surface of the sand. Two lines of evidence strongly support the presence of internal residues.

Three sets each of corn and wheat were grown simultaneously under the same environmental conditions. One set of plants was treated as follows: The 2 inches of plant material above the cutting point (see Figure 7) were rinsed in acetone immediately after harvest. A second group was grown in sand covered with a 0.5-cm. layer of paraffin shavings. The third set was grown normally without any substrate covering. It was assumed that if volatilization of dieldrin occurred and surface contamination were significant, the three sets of plants would have different residue levels. Not only did the three sets of plants contain essentially equal insecticide concentrations, but analysis of the acetone rinse revealed only very small quantities of dieldrin, which constituted about 1 to 5% of the total found.

The second piece of evidence was obtained through the use of control plants, grown in substrates containing no added dieldrin and analyzed along with the experimental plants. These blank samples frequently contained small quantities of the insecticide. The levels (approximately 1 to 3% of that found in treated samples) were always subtracted from the experimental values. It was assumed that the insecticide found in the analysis of the control plants constituted surface residues. The dieldrin in excess of these control levels was considered to be internal.

After establishing the capability of the plants to absorb and translocate this chloro-organic insecticide, investigations were initiated to study this phenomenon extensively. Plants were grown in substrates containing varying dieldrin concentrations for short periods of time (3 to 6 weeks) and the uptake of dieldrin was measured. The next five figures illustrate the data obtained.

Figure 2 shows the insecticide levels found in corn, wheat, alfalfa, and orchard grass grown in sand. Wheat and orchard grass possessed the highest dieldrin levels, while alfalfa absorbed intermediate levels and corn contained the lowest concentrations.

Figure 3 illustrates the plant levels of insecticide when grown in soil. Wheat again accumulated the highest dieldrin concentration. Alfalfa and orchard grass were intermediate and corn possessed the lowest levels.

The uptake of dieldrin by plants seems to depend in part upon the plant species. Two of the monocotyledonous plants (wheat and orchard grass) absorbed and translocated as much as or more dieldrin than the only dicotyledonous plant (alfalfa). Corn, wheat, and orchard grass representing three genera of the grass family appear to have different uptake capabilities.

Environmental changes such as temperature, humidity, and rain, also affect the uptake of dieldrin by plants. Small environmental changes caused variations in the levels found in any one species. However, the general uptake curves always followed the same patterns (Figures 2 and 3).

A third factor governing dieldrin uptake is the type of substrate. The differences in uptake by plants from sand and soil are illustrated with wheat in Figure 4. The plants grown in sand contained from two to five times the dieldrin levels of similar soil-grown plants. This is generally true for the three other species as well (Figures 2 and 3).

When plants were grown in sand, there was a general sharp rise in dieldrin concentration as the substrate level increased from zero to approximately 5 p.p.m. At higher concentrations in the sand the change in the dieldrin content of the plant was relatively small and tended to level off. This is not typical for soil-grown plants. There was a more nearly linear increase of dieldrin levels in the plant in relation to soil concentrations over the entire range than in sand.

The smaller insecticide residues found in soil-grown plants and the differences in the shape of the uptake curves may be due, at least in part, to binding of dieldrin to soil particles and organic matter. Probably of equal importance is a general reduction in availability of the insecticide created by soil microorganisms. Experience has shown that algae are capable of accumulating the compound; and Korte, Ludwig, and Vogel (*4*) have reported the metabolism of dieldrin by soil fungi. These

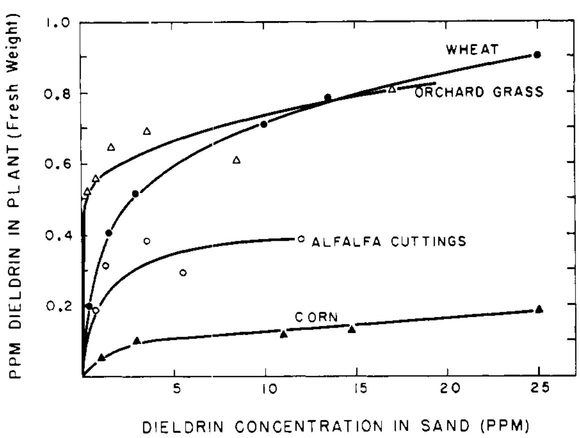

Figure 2. Uptake of dieldrin by four plant species from sand

facts are of great practical significance for field-grown crops.

Differences in dieldrin levels found in two successive cuttings of wheat plants are illustrated in Figure 5. These plants were grown in sand for 3 weeks, harvested, processed, and analyzed. The same plants were allowed to grow for 3 more weeks and then a second cutting was made. In general, the second cuttings contained dieldrin levels 10 to 25% higher than the first cuttings.

Figure 6 shows the localization of dieldrin within the aerial parts of 3-week-old wheat plants. The "stems" (see Figure 7 for definitions of "stems" and "tops") have far higher levels of the insecticide than the remaining aerial portion of the plant. This fact helps to explain the higher dieldrin concentrations in the second cuttings as illustrated in Figure 5. The meristematic region included in the stems had considerably more

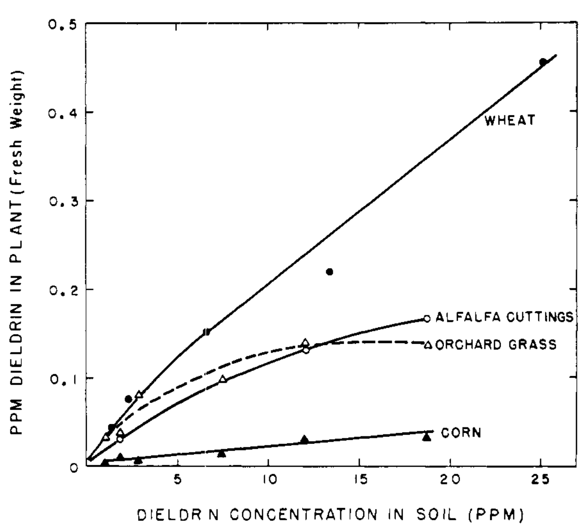

Figure 3. Uptake of dieldrin by four plant species from soil

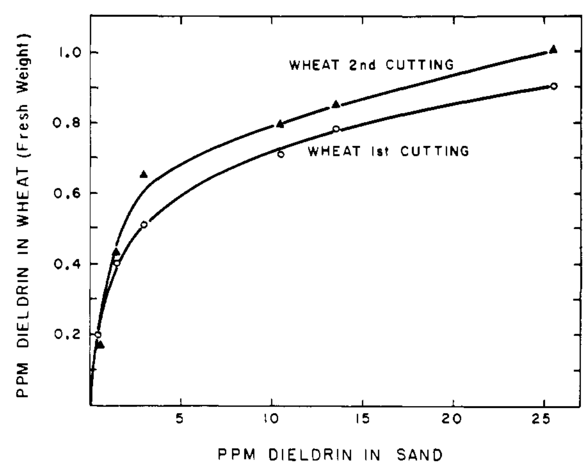

Figure 5. Dieldrin levels in two successive cuttings of wheat

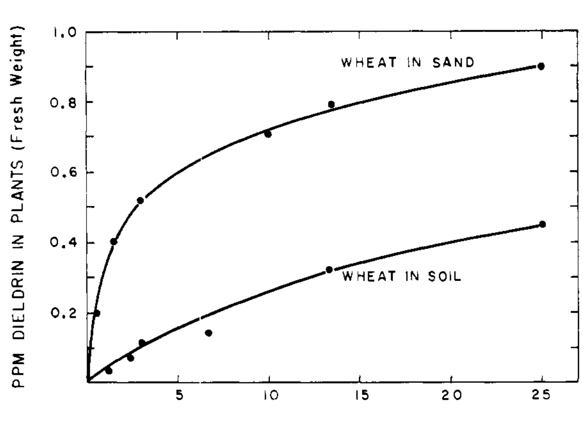

Figure 4. Uptake of dieldrin by wheat from sand and from soil

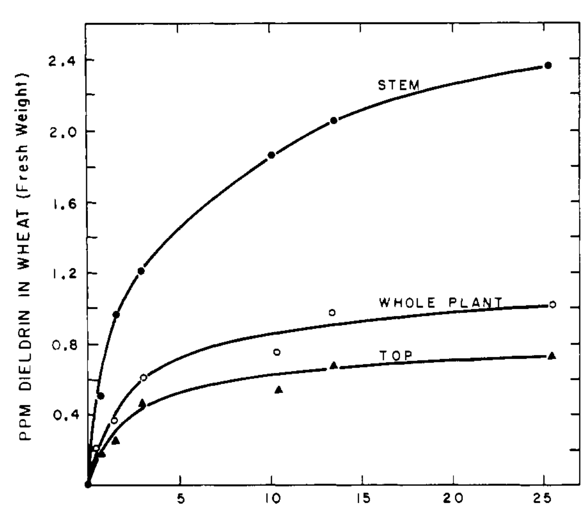

Figure 6. Localization of dieldrin within wheat plant

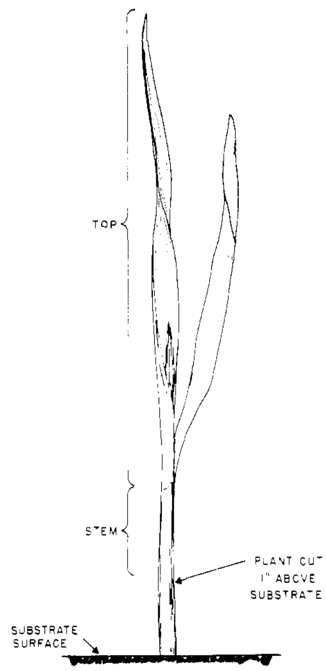

Figure 7. Definitions of "stems" and "tops" of wheat plants

insecticide than the tops. Also, the higher concentrations may be attributed to more extensive root systems. By the second cutting the area immediately above the meristem would have moved up and become a part of the tops. King *et al.* (*3*) have reported the same phenomenon for heptachlor epoxide in alfalfa. The second cuttings always had higher residues than the first. The partial rationale suggested for wheat cannot, of course, apply to alfalfa.

Thus, forage crops are able to absorb and translocate dieldrin from the substrate. The fact that the concentration of insecticide found within the plant varies greatly with the type of substrate might be considered when recommending application rates. Plants grown on sandy soils would be expected to absorb considerably more dieldrin than plants grown on soils containing high percentages of organic matter.

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