Persistence of Dieldrin, Lindane, and DDT in a Light Sandy Soil and their Uptake by Grass

by S. VOERMAN

Laboratory for Research on Insecticides, Marijkeweg 22, Wageningen, the Netherlands

and

A. F. H. BESEMER

Plant Protection Service, Geertjesweg 15, Wageningen, the Netherlands

An important problem in relation to the use of chlorinated hydrocarbon insecticides is their persistence in soil (THAKRE 1973, LICHTENSTEIN et al. 1971, VOERMAN and BESEMER 1970). They can be taken up by the roots of plants and from there be transported to aerial parts (WHEELER et al. 1967, BEITZ et al. 1970, NASH et al. 1970, NASH and BEALL 1970, NASH and HARRIS 1973). In the Netherlands DDT and related compounds were found in milk of cows grazing on pastures where formerly fruit trees or field crops (especially sugar-beets) were grown.

In order to obtain more quantitative information about uptake and transport of dieldrin, lindane and DDT, samples of grass and grass-roots, grown on a light sandy soil, contaminated with 3 concentration levels of these insecticides, were investigated. Up to 1968 these insecticides had been used on small experimental fields for 15 subsequent years. Since then these fields have not been treated with any of the insecticides. In 1973 the soil was sampled. The results of the analyses are reported in this paper and compared with those of 1969 (VOERMAN and BESEMER 1970). Also the roots and the leaves of ryegrass grown on these fields during 1973 were investigated for insecticide content.

Materials and Methods

A part of the experimental field of the Plant Protection Service at Wageningen was subdivided in small fields of 4.2 x 2.8 m by sunken concrete slabs. The soil was light sandy and contained about 3% organic matter. Dieldrin, lindane, and DDT were used regularly throughout a period of 15 years. Each insecticide (of technical quality) had been applied on 3 plots. On the B and C plots a water emulsion of the insecticide was sprayed on the crops. The C plots received twice the amount of the B plots. Soil contamination in these plots resulted from run-off of the spray during the application, and the washing-down by rain afterwards. Once a year a water emulsion was directly poured onto the soil of the D plots before sowing or planting. The regular treatments were carried out from 1953-1968. Soil samples were taken to a depth of 60 cm in layers of 10 cm in January 1969. The results of the analyses of these samples have been reported by VOERMAN and BESEMER (1970).

Bulletin of Environmental Contamination & Toxicology,
Vol. 13, No. 4 ©1975 by Springer-Verlag New York Inc.

In 1969 the fields were left fallow, in 1970 peas were grown and in 1971 and 1972 rye. In March 1973 grass was sown (species: perennial ryegrass, Lolium perenne L., variety: Pelo). The grass was mown on June 12, July 27, and September 10.

Soil samples were taken on September 6. In each plot at least 5 drilling operations were performed to a depth of 60 cm (hole diameter 3.6 cm). The samples of each layer of 10 cm taken from the same plot were collected in a plastic bag and stored in a freezer. They were extracted as described earlier (VOERMAN and BESEMER). The extracts were dried with $MgSO_4$ prior to GLC. Samples of grass and grass-roots were taken on September 25 and stored at ice-box temperature. They were washed thoroughly with water to remove adhering soil particles. The upper ends of the roots were removed as where the lower ends of the grass blades. The roots were cut up into short pieces with scissors and the grass by a Hobart food-chopper. Subsamples of this material were extracted in a Bühler homoginator with a 2 : 1 mixture of benzene and 2-propanol (10 g roots or 25 g grass with 60 ml). The extracts were washed with a 5% Na_2SO_4 solution and about 5 ml extract was dried with $MgSO_4$. After a few hours 0.5 g Florisil (activated at 130°C for 4 hours) was added. After standing overnight the extracts were ready for GLC. The analyses were performed on a Varian Gas Chromatograph, Model 204-1B equipped with a tritium electron-capture detector using a glass column: 1.7 m x 3 mm packed with 4% SE-30/6% SP-2401 on Supelcon 100/120, AW-DMCS (Supelco, Inc.).

All calculations were based on the oven-dry weight of the samples (105°C until constant weight was attained).

Results and Discussion

The table shows the results of the analyses of the samples taken in 1973 together with the residues found in the soil in 1969. In 1969 the soil was sampled in January before digging which explains the lower concentrations in the 10-20 cm layer that year. Each year the soil was dug before sowing or planting. In this way the 2 top layers were mixed very well.

It is evident that during the 4 years since the last treatment there has been no significant decrease in the total amounts of dieldrin, p,p'-DDT, and o,p'-DDT in the soil. The apparent slight increase may be the result of minor changes in sampling or analytical methods. The p,p'-DDE concentrations had more than doubled since 1969. Only the lindane residues were significantly lower than in 1969.

Transport in lower layers was very small. The discontinuity on layer 40-50 cm of plot D treated with DDT, could have been caused by an error in sampling (falling of some soil out of the top layer into a drilling hole).

The concentrations in the roots were 5-15 times higher than found in the surrounding soil. Only relatively small quantities were found in the grass.

TABLE

Quantities (in ppm) of dieldrin, lindane, p,p'-DDT, o,p'-DDT, and p,p'-DDE estimated in a light sandy soil compared with the amounts present 4.75 years ago. Quantities found in aerial and root parts of grass grown on these plots are also recorded.

Compound	Plot	Year	Residues in ppm (µg/g)							
			Grass	Roots	Soil layer in cm					
					0–10	10–20	20–30	30–40	40–50	50–60
Dieldrin	B	1969	–	–	1.25	0.23	0.02	0.01	...	...
		1973	0.05	11.6	0.77	0.71	0.17	0.03	0.02	0.04
	C	1969	–	–	2.29	0.86	0.02	0.01	...	...
		1973	0.18	24.2	1.73	1.72	0.33	0.04	0.02	0.02
	D	1969	–	–	7.33	2.50	0.05	0.03	0.02	0.01
		1973	0.40	75.5	7.3	8.0	1.3	0.25	0.10	0.11
Lindane	B	1969	–	–	0.09	0.01	...	...	...	...
		1973	...	...	...	...	...	...	...	...
	C	1969	–	–	0.34	0.07	...	...	...	...
		1973	...	0.26	0.03	0.02	...	...	...	...
	D	1969	–	–	1.30	0.23	...	...	...	...
		1973	0.10	2.2	0.32	0.35	0.10	0.11	...	0.01
p,p'-DDT	B	1969	–	–	3.53	0.56	0.01	0.01	...	...
		1973	0.04	17.3	2.45	2.36	0.36	0.07	0.04	0.01
o,p'-DDT		1969	–	–	0.78	0.07	...	...	...	...
		1973	0.05	3.96	0.63	0.58	0.08	0.02	...	...

TABLE (continued)

Compound	Plot	Year	Residues in ppm (µg/g)							
			Grass	Roots	Soil layer in cm					
					0–10	10–20	20–30	30–40	40–50	50–60
p,p'-DDE	B	1969	-	-	0.39	0.07	...	...	...	...
		1973	0.06	2.98	0.44	0.42	0.10	0.02	0.01	0.01
p,p'-DDT	C	1969	-	-	8.94	1.05	0.02	0.01	0.01	...
		1973	0.32	60.0	5.8	5.6	0.98	0.13	0.08	0.06
o,p'-DDT		1969	-	-	1.77	0.22	...	...	...	...
		1973	0.07	11.1	1.5	1.4	0.24	0.03	...	0.01
p,p'-DDE		1969	-	-	0.77	0.11	0.01	0.01	...	...
		1973	0.09	9.6	1.2	1.1	0.21	0.04	0.02	0.02
p,p'-DDT	D	1969	-	-	59.6	9.22	0.15	0.10	0.11	0.13
		1973	1.2	285	42.5	37.3	2.7	0.36	1.9	0.19
o,p'-DDT		1969	-	-	12.9	2.02	0.04	0.02	0.02	0.02
		1973	0.28	67.5	12.2	11.0	0.83	0.10	0.46	0.05
p,p'-DDE		1969	-	-	3.33	0.51	0.02	0.02	0.02	0.02
		1973	2.79	25.2	4.5	4.4	0.42	0.06	0.16	0.03

- means: not determined
... means: less than 0.01 ppm

Thompson et al. (1963) also found little or no uptake of DDT in ryegrass cut 8 and 13 weeks after sowing in soil containing DDT. It is possible that a part of these residues occurred on the surface of the grass and on the roots as they were only washed with water prior to extraction.

In the plots treated with DDT it was difficult to estimate the concentration of p,p'-TDE (p,p'-DDD) in the soil among the large quantities of o,p'-DDT and p,p'-DDT. Its concentration in plot D was estimated to be less than 0.3 ppm. However, grass-roots in plot B contained 0.48 ppm, in plot C 1.7 ppm, and in plot D 8.0 ppm p,p'-TDE.

Acknowledgment

The authors thank Dr G.C. Ennik for managing the grass planting and Mr H. Janssen for his assistance with the analyses.

References

BEITZ, H., J. HARTISCH, F. SEEFELD, and E. HEINISCH, Arch. Pflanzenschutz 6, 99-112 (1970).

LICHTENSTEIN, E.P., T.W. FUHREMANN, and K.R. SCHULZ, J.Agr.Food Chem., 19, 718-721 (1971).

NASH, R.G., M.L. BEALL,Jr., and E.A. WOOLSON, Agron.J. 62, 369-372 (1970).

NASH, R.G. and M.L. BEALL,Jr., Science 168, 1109-1111 (1970).

NASH, R.G. and W.G. HARRIS, J.Environ.Quality 2, 269-273 (1973).

THAKRE, S.K., Pesticides, 25-29 (1973).

THOMPSON, F.B., P.M. BATES, and H.J. TAILOR, Proc. New Zealand 16th. weed control conference 114-115. New Zealand Dep. Agr. Wellington (1963).

VOERMAN, S., and A.F.H. BESEMER, J.Agr.Food Chem. 18, 717-719 (1970).

WHEELER, W.B., D.E.H. FREAR, R.O. MUMMA, R.H. HAMILTON, and R.C. COTNER, J.Agr.Food Chem., 15, 231-234 (1967).