Bull. Environ. Contam. Toxicol. (1988) 41:569–573

Environmental Contamination and Toxicology

Loss of Trifluralin from Clay and Loam Soils Containing Aged and Freshly Applied Residues

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When pesticide residues remain in contact with soils under field conditions for extended periods, a phenomenon known as aging, or weathering, can occur. The mechanisms of aging are not clearly understood, although it is generally considered that they involve an increased adsorption of the chemicals to soil colloids (Adams 1973; Chiba 1969; Hamaker and Goring 1976; Saha et al. 1969) and a diffusion of the pesticide molecules into clay and humic colloids (Adams 1973; Khan 1973). These processes may provide protection from microbial breakdown, chemical decomposition, and volatilization losses by reducing the concentration of the pesticide in the soil solution. Thus, decreased dissipation rates could result.

Experiments have been carried out, under controlled laboratory conditions, to determine the rates of soil dissipation of aged herbicide residues compared to those from freshly applied material. It has been reported (Byast and Hance 1981) that aged residues of linuron disappear more slowly from soil than freshly applied chemical. In contrast, both aged and fresh residues of simazine (Byast and Hance 1981) and triallate (Smith and Milward 1985), undergo breakdown at similar rates.

The soil-applied herbicide trifluralin is extensively used in western Canada; the herbicide is persistent and carry-over of residues from one crop year to the next occurs (Smith 1982). Trifluralin is also strongly adsorbed to soil organic matter (Grover et al. 1979). To determine whether the dissipation of trifluralin is modified by aging processes, the rates of breakdown of the herbicide remaining in clay and loam field soils, that had been treated 10 months previously, were compared to the dissipation rates in the same soils receiving fresh herbicide treatments.

MATERIALS AND METHODS

The field soils were a clay and a loam from the vicinity of Indian Head, Saskatchewan. The texture analysis of the former was 71% clay, 5% sand and 24% silt, while the same figures for the loam were 26%, 42% and 32%, respectively. The soil pH of the clay was 7.9 and for the loam, 7.4. Organic matter content of the former was 2.9%, and for the latter, 4.6%. The wilting points were 40% for the clay and 35% for the loam.

A commercial 5% granular formulation of trifluralin was applied to a field plot at each location at a rate of 2.7 kg/ha (twice the normal application) during October, 1986 and incorporated to a depth of 9 cm using a field cultivator with attached harrow. In April of 1987, a second incorporation, 9 cm in depth, was carried out and four days later a third incorporation, to 7.5 cm, was effected. Control plots, left untreated but cultivated as described, provided herbicide-free soil. Both treated and untreated areas were seeded with mustard (Brassica juncea (L.) Coss.) in May, 1987.

In August, 1987, 10 months after treatment, 15 cores (7.5 cm in diameter) were randomly collected from the top 10 cm depth of the trifluralin-treated field soils and pooled. Immediately after collection, the soil was poured 20 times through a Riffle sampler to evenly distribute the herbicide throughout the soil. A similar number of soil cores were taken from the control plots and thoroughly mixed, as before. Replicate samples (4 x 50 g) of the treated and untreated soils were analyzed (see later) for trifluralin. The clay contained 1.11 ± 0.09 µg/g and the loam 1.58 ± 0.06 µg/g trifluralin, respectively. Control soils showed <0.001 µg trifluralin per g soil.

Aliquots of the trifluralin-containing field soils were weighed into 175-mL capacity polystyrene cartons and moistened with sufficient distilled water to give samples (50 g) at 85% of their respective field capacities. The cartons were loosely capped, to allow air exchange, and incubated in the dark at 20 ± 1°C. For comparative purposes, samples (50 g) of the herbicide-free soil were treated with a solution of trifluralin (1.00 mg/mL methanol) so that the herbicide concentrations in the control soils were the same as in the clay and loam soils containing the aged residues. The control soils were treated with trifluralin at the same rates as those remaining in the treated field soils to preclude any concentration effects that might influence the rates of dissipation. After thorough stirring to distribute the trifluralin, distilled water was added to moisten the control soils to 85% of their field capacities, and the loosely capped cartons placed in the incubator. Distilled water was added to all cartons (by weight) every second day to maintain the moisture. Duplicate samples from the four treatments were extracted and analyzed for trifluralin remaining after 0.1, 14, 28, 56 and 84 days.

At the various sampling times, the soil from each carton was extracted with 20% aqueous acetonitrile containing 2.5% of glacial acetic acid using an overnight extraction procedure. Trifluralin was partitioned into hexane and quantified gas chromatographically. Details of this extraction procedure have already been reported (Smith 1981).

RESULTS AND DISCUSSION

Trifluralin is lost from soils maintained under aerobic conditions by chemical and biochemical processes (Golab et al. 1979; Helling 1976) and by volatilization (Helling 1976; Soderquist et al. 1975;

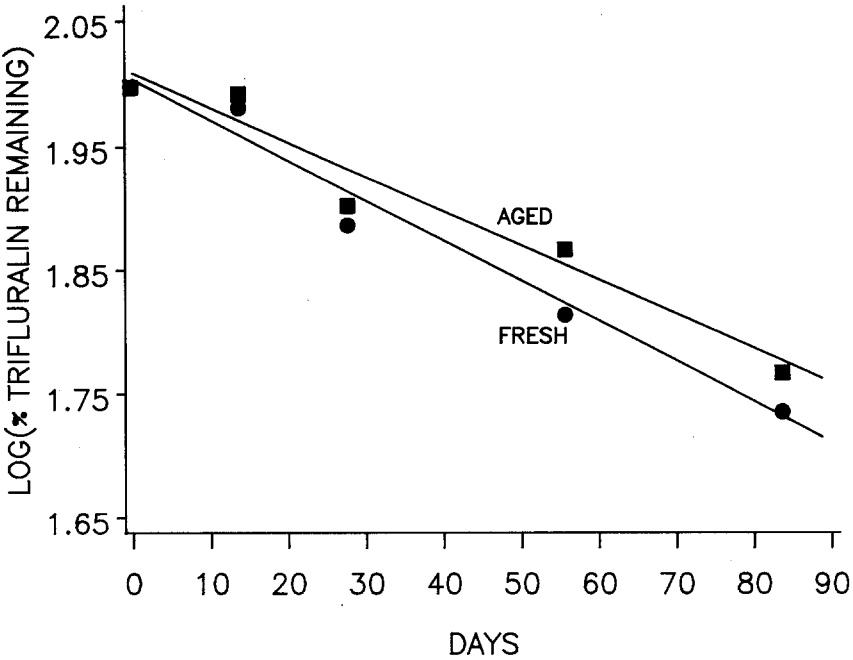

FIG.1 LOSS OF AGED (■) AND FRESH (●) TRIFLURALIN FROM CLAY

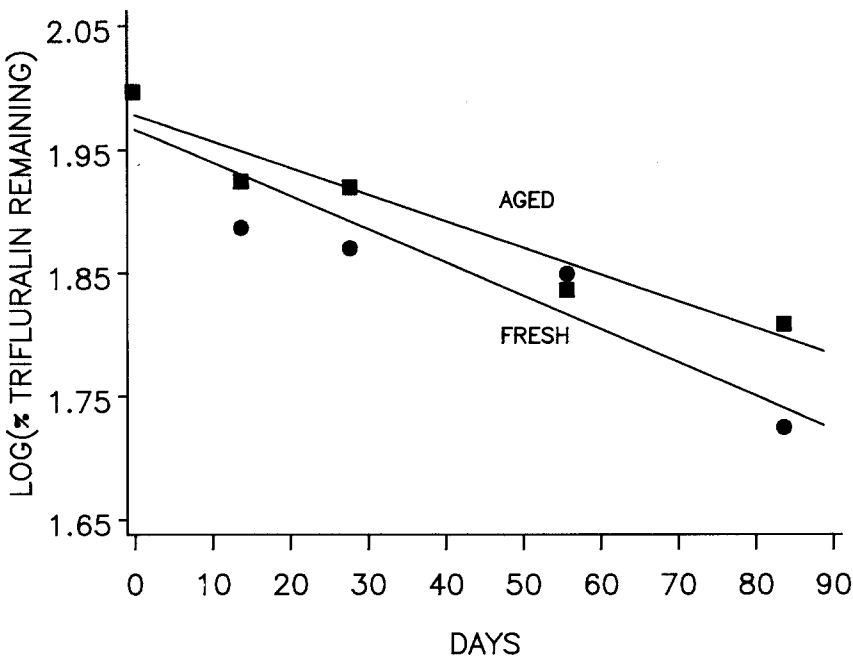

FIG.2 LOSS OF AGED (■) AND FRESH (●) TRIFLURALIN FROM LOAM

Spencer and Cliath 1974; White et al. 1977). In the present study, each of these processes would contribute to the depletion of trifluralin from the treated soils.

When pesticide residues are aged and become more strongly adsorbed onto soil colloids they are also more resistant to solvent extraction (Chiba 1969; Saha et al. 1969; Smith 1981; Smith and Milward 1983). Choice of extraction procedure is, therefore, important for the recovery of the aged trifluralin residues from the field soils. An earlier study (Smith 1981) indicated that aqueous acetonitrile containing a small amount of acetic acid, in combination with an overnight extraction, consistently recovered greater amounts of aged trifluralin residues from a variety of soils than did several other solvent systems and extraction procedures. This method was adopted for the present study to ensure efficient trifluralin recoveries. For all soils, at all sampling times, the reproducibility between duplicate soil analyses was excellent.

The losses of aged and freshly applied residues of trifluralin from the clay and loam under laboratory conditions are compared in Figs. 1 and 2. During the 84-day incubation period between 35 and 47% of the herbicide was lost from the soils. In all cases, the rates of trifluralin dissipation showed a greater correlation with first-order kinetics than linear. The regression equations for the dissipation of trifluralin from the various soils, together with the extrapolated half-life values (time for 50% of the herbicide to be dissipated), are summarized in Table 1.

Table 1. First-order dissipation equations for aged and freshly applied residues of trifluralin in clay and loam soils over an 84-day incubation period at 20°C and 85% of field capacity.

Soil	Treatment	Log_{10} (% herbicide) at T days	RMS*	Half-life (days)**
Clay	Aged 10 months	2.009 - 0.00279T	0.96	(111)
	Fresh	2.004 - 0.00325T	0.97	(94)
Loam	Aged 10 months	1.979 - 0.00217T	0.94	(129)
	Fresh	1.967 - 0.00271T	0.88	(99)

* Regression mean square. ** Extrapolated half-life values.

For each soil type there was no statistical difference, at the 0.95 confidence level, between the rates of trifluralin dissipation from freshly applied and aged residues over the 84-day incubation period. Trifluralin is, therefore, similar to simazine (Byast and Hance 1981) and triallate (Smith and Milward 1985) in that aged residues dissipate from soils at similar rates to those of freshly applied chemical. Thus, any increased adsorption of trifluralin to field soils as a result of aging, does not significantly reduce the availability of the herbicide to dissipation processes.

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Received December 7, 1987; accepted May 15, 1988.