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Effects of Thiram and Terbuthylazine on Cellulose Decomposition in Two Soils

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Organic matter decomposition is one of the most important processes occurring in the soil. Any major change in its rate and extent can cause marked practical problems for agriculture. For example, a reduction in decomposition of straw and stubble may result in accumulation on the soil surface of trash which may harbor plant pests and pathogens (Jeater and McIlvenny 1965; Moore and Thurston 1970). Other implications include the potential transfer of herbicide residues from treated trash to subsequent crops (Jeater and McIlvenny 1965).

Grossbard and Cooper (1974) demonstrated that barley straw sprayed with paraquat (at a rate equivalent to 1.7 kg/ha) and subsequently buried in soil decomposed at a markedly slower rate than untreated straw. This is not surprising since Wilkinson and Lucas (1969) previously demonstrated that fungal colonization on potato haulm was reduced following paraquat treatment. When applied to soil, however, this herbicide showed variable effects on cellulose decomposition and number of microbial propagules (Tu and Bollen 1968; Grossbard et al. 1972; Szegi 1972; Camper et al. 1973).

It is also evident that the changes in fungal population of soil treated with fungicides may be due to the direct effects of chemicals on soil fungi or to the fungicide's alteration of physico-chemical properties of the soil (Wainwright and Pugh 1975). For example, the application of fungicide has been shown to reduce organic matter decomposition and contribute to the accumulation of organic matter which may influence nutrient status of the soil and consequently reduce microbial activity (Alexander 1965). However, little information is available concerning their effect on cellulose decomposition.

Herbicides are used in larger quantities than other agricultural pesticides. Their effects on soil microbial activity are of considerable concern and importance. In general, the influence of the triazine group on soil microflora has been extensively studied (Fryer et al. 1979), but little work has been done with

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terbuthylazine, especially concerning its effect on soil microbes.

The rate of cellulose decomposition in soil is affected by many factors, such as soil type and climate. As yet little is known about the interaction between herbicides, organic matter decomposition and soil factors. Bearing in mind the importance of the organic matter cycle in soil, especially in light of increasing use of minimum tillage procedures, it is essential that more attention be paid to the side effects of herbicides on cellulose decomposition.

In studies on cellulose decomposition, artificial substrates such as cotton cloth or filter paper are often used because they are easier to handle and results are more reproducible than those obtained with naturally-occurring cellulosic materials. This paper reports the results of experiments in which an artificial cellulosic substrate was used to investigate the effects of thiram and terbuthylazine on cellulose decomposition.

MATERIALS AND METHODS

Two soil types were used in these experiments. Soil I was obtained from a corn field at Universiti Pertanian Malaysia, Serdang. Soil II was from the experimental plot of Universiti Kebangsaan Malaysia, Bangi. Some physico-chemical properties of both soils are shown in Table 1. The soils were sifted through a 3-mm sieve and placed in black polyethylene bags. The 100% cellulose substrate, specially made for soil burial test, was obtained from British Textile Technology Group. Pesticides tested were thiram as Thiram™ (Ancom Malaysia): active ingredient 80% w/w tetramethyl thiuram disulphide; and terbuthylazine as Gardoprim ™ (Ciba-Geigy): active ingredient 500 g/L 2-tert-butylamino-4-chloro-6-ethylamino-1,3,5-triazine.

Both sides of a single layer of the substrate were sprayed with thiram (rate equivalent to 8 and 32 kg/ha) or terbuthylazine (rate equivalent to 0.5 and 2.0 kg/ha). The concentrations used were at the recommended and four times the recommended rate. The substrate was then cut into strips of 2 cm x 11 cm and mounted onto glass slides for burial in soil as described by Greaves et al. (1978). Five cloth-covered slides were placed sideways in the soil in a box. The box was filled with more moist soil (700 g) using a glass rod to make the soil firm between the slides to ensure good contact between soil and cloth. Ten replicates of cloth strips placed, five each, in two boxes of soil were prepared for each treatment. The boxes were then placed in polyethylene bags which were secured with elastic bands and then inflated using a compressed air supply. Each box was weighed and incubated at 27 C for up to 6 wk. The moisture content of the treated and control soils was adjusted to 50% of the field capacity.

In another set of experiments, each pesticide was mixed

Table 1. Soil characteristics

	Soil I	Soil II
pH	4.0	4.0
Organic carbon (%)	0.4	0.7
Nitrogen (%)	0.1	0.5
Sand (%)	68.0	45.0
Silt (%)	3.0	35.0
Clay (%)	29.0	20.0
CEC (meq/100 g)	5.9	5.2

thoroughly with the soil to give final concentrations of 20 and 150 ppm for thiram and terbuthylazine, respectively, on dry weight basis. Untreated substrate was then buried in the treated soil either immediately or after this soil had been stored for 4 wk at 27 C. The substrate was incubated for 6 wk before weight loss was determined.

After incubation, the slide-mounted substrate was carefully removed from the soil and soil particles gently removed from the cloth using a small artist's brush. The cloth strip was oven-dried for 24 hr at 50 C and cooled in a desiccator before weighing. The weight loss was calculated as a percentage of the weight of an identical piece of cloth which had not been buried. Data were subjected to an analysis of variance with mean separation by Duncan's multiple range test.

RESULTS AND DISCUSSION

A significant reduction in cellulose decomposition in both soils was observed when the substrate had been treated with thiram (Table 2). At 32 kg/ha, thiram reduced cellulose decomposition in Soil I and Soil II by 80 and 33% of control, respectively. These results showed that thiram exerted an inhibitory effect on cellulose decomposition at higher rates. Thiram residue may remain on the substrate, enhancing its effect on cellulolytic fungi. On the contrary, terbuthylazine did not show any inhibitory effect when it was applied to the substrate. No significant difference was observed between control and the 2.0 kg/ha of terbuthylazine treatment.

The effects of thiram and terbuthylazine on decomposition of cellulosic materials buried in soil immediately following treatment of the soils are shown in Table 3. The results indicate that thiram reduced the decomposition rate of the substrate in both soils and this reduction was proportional to the concentration used. Treatment of soil I and II with 150 ppm of thiram caused a reduction in the weight loss by 50 and 37% of control, respectively. In contrast, when soils I and II were treated with terbuthylazine at 20 ppm, the decomposition rate appeared to be enhanced. However, at 150 ppm, no significant increase as compared to control was observed when the substrate

Table 2. Decomposition of the substrate treated with thiram or terbuthylazine buried in untreated soil.

Pesticide (kg/ha)		Weight loss (% of initial weight) Soil I	Soil II
Thiram	0	5a	30a
	8	4a	24ab
	32	1b	20b
Terbuthylazine	0	5a	30a
	0.5	7a	29a
	2.0	7a	28a

Means within a column for each pesticide followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

was incubated in Soil II (Table 3).

Incubation of the treated soil for 4 wk before burial of the substrate did not appear to reduce the inhibitory effects of thiram on cellulose decomposition in both soils (Table 4). In Soil I, the inhibitory effect was similar to that buried immediately following treatment of the soil. But in Soil II, there was no significant effect on cellulose decomposition. In the case of terbuthylazine-treated soil, enhancement of substrate decomposition was again observed in Soil I but not in Soil II.

The results of this study show that thiram had deleterious effects on cellulose decomposition when applied either directly to the substrate or to the soil. The known antifungal action of thiram probably explains, at least in part, its inhibitory effect on the degradation of cellulose. Simon-Sylvestre and Fournier (1979) have shown that soil fungi are affected by thiram. The deleterious effects of thiram may be explained by the fact that the fungicide is a carbamate compound containing a thiol radical which readily combines with non-protein thiols (-SH) and hydroxyl (-OH) groups of enzymes in the fungal cell. In the soil, this compound readily breaks down to produce carbon disulphide and thiophosgen which are themselves deleterious. Hence, the fungicide and its breakdown products can have an inhibitory effect on fungal growth. This could be related to the fact that thiram kills cellulolytic fungi which normally colonize the substrate.

It is well known that organic carbon content has a major influence on adsorption of herbicides onto soils, thus influencing their activity on plants and on the microorganisms in the soil. For example, Rahman et al. (1978) have shown that the phytotoxicity of atrazine decreased with increasing soil organic matter content. Adsorption of paraquat onto humus in soils has

Table 3. Effects of thiram and terbuthylazine on decomposition of cellulosic material which were buried in soil immediately after treatment of soil. The values represent weight loss as % of initial dry weight.

Soil	Pesticide	Concentration (ppm) 0	20	150
Soil I	Thiram	4a	4a	2b
	Terbuthylazine	4b	13a	13a
Soil II	Thiram	27a	24b	17c
	Terbuthylazine	27b	33a	28b

Means within corresponding rows followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

Table 4. Effects of thiram and terbuthylazine on decomposition of cellulosic material in treated soil preincubated for 4 wk before burial of substrate. The values represent weight loss of substrate as % of initial dry weight.

Soil	Pesticide	Treatment of soil (ppm) 0	20	150
Soil I	Thiram	4a	4a	2b
	Terbuthylazine	4b	9a	10a
Soil II	Thiram	27a	24a	23a
	Terbuthylazine	27a	28a	30a

Means within corresponding rows followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

been reported to reduce inhibitory effects of the herbicide on cellulose decomposition (Szegi 1972).

The present work also shows that terbuthylazine has no significant adverse affects on the decay of cellulosic substrate in the soil. Grossbard (1974) has shown that other herbicides, such as glyphosate, enhanced cellulose decomposition in the soil. Other herbicides in the same group as terbuthylazine, such as atrazine and simazine, stimulated the activity of cellulolytic organisms (Spiridonov and Jakolev 1968). Terbuthylazine is more readily adsorbed on to soils containing a higher content of clay and organic matter. Downward movement or leaching of the herbicide is limited by its adsorption to certain soil consituents (Bowman 1989). Soil II has a higher organic content than Soil I, which may explain the lack of either inhibition or stimulation of cellulose decomposition in Soil II, even after the soil had been preincubated for 4 wk before burial. Herbicides are also strongly adsorbed onto the substrate as reported by Grossbard and Atkinson (1985) for glyphosate. Perhaps this explains why terbuthylazine, sprayed onto the substrate had no significant effect on the decomposition rate.

These results clearly show that the differing characteristics of the two soils had a marked influence on the decomposition of cellulose and its interaction with terbuthylazine. It is noteworthy that the decomposition rate was higher in Soil II even without the treatment. Differences in microbial population between the two soils may contribute to this phenomenon; however, further study is needed to verify these results. The higher contents of organic carbon and nitrogen may contribute to higher microbial populations in Soil II.

As yet little is known about the interaction of herbicide, organic matter decomposition, and soil factors. It is obvious that many factors including soil type, storage time and moisture content can influence the response of the cellulolytic microorganisms to the pesticides under laboratory conditions. These factors may modify the decomposition activity of the microflora and so alter their ability to colonize and degrade cellulosic materials.

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