PATTERN OF DISSIPATION OF SOME SOIL-APPLIED HERBICIDES

A. RAHMAN, B. BURNEY and B E. MANSON
Soil and Field Research Organisation
Ruakura Agricultural Research Centre, MAF, Hamilton

Summary

Results from time-rate disappearance studies with alachlor, linuron, and atrazine on Horotiu sandy loam soils are presented. Soil samples were collected from field plots at monthly intervals and bioassayed in the glasshouse for herbicide residues. The organic matter content of the soil influenced the persistence of all three herbicides as in most cases phytotoxic effects were recorded for a longer period in the lowest organic matter soil compared to those containing high organic matter levels.

INTRODUCTION

Results of field trials conducted by Rahman *et al* (1975) in different parts of New Zealand showed that alachlor and linuron applied at rates of up to 8 and 4 kg/ha respectively, did not persist in phytotoxic amounts at the end of the cropping season (6 months after application). Atrazine showed small residues in some trials from the rate of 2 kg/ha and the residual activity was affected by the organic matter content of the soil. From the practical point of view it is the residual activity of the herbicide at the end of a cropping season which is of most concern, but it would be useful to know the actual time and pattern of disappearance of the compound from different rates of application. In addition to providing a better understanding of the herbicide's fate in soil, such information would be valuable in situations where a susceptible crop has to follow in rotation earlier than usual.

This paper reports results from time-rate dissipation studies with alachlor, linuron, and atrazine applied at different rates. Trials were conducted on three sites to obtain further information concerning the effect of soil organic matter on persistence of these herbicides.

MATERIALS AND METHODS

Three field trials were conducted on the Horotiu sandy loam soil near Hamilton during the 1974 - 75 cropping season. These sites were especially selected to provide a range of organic matter content whilst retaining comparable soil textures. Some chemical and physical properties of the soils are presented in Table 1. The mechanical analyses were performed by the pipette method and all other properties were determined by the Ruakura Soil Testing Laboratory using its standard techniques.

TABLE 1 : SOME CHEMICAL AND PHYSICAL PROPERTIES OF THE SOILS USED

Site	*Organic matter* (%)	(*t/ha*)*	*Sand* (%)	*Clay* (%)	*C.E.C.* (*me./100 g*)	*pH*	*Field capacity* (%)
1	9.8	70.6	64.9	15.1	33.5	5.8	42.8
2	15.5	108.5	60.4	14.5	39.3	6.0	42.4
3	20.6	138.1	58.9	15.5	40.1	6.1	44.1

* In top 10 cm

The concentrations of herbicides ranged from 1 - 8 kg/ha for alachlor, 1 - 4 kg/ha for linuron and 0.5 - 2 kg/ha for atrazine. Soya beans (*Glycine max* cv 'Amsoy') and oats (*Avena sativa* cv 'Mapua') were grown as indicator plants to test the phytotoxicity of herbicides in the field. Individual plots were 2 × 6 m and treatments were arranged in a randomised block design with four replications. The herbicides were surface applied as pre-emergence treatments in a spray volume of 350 litres/ha at a pressure of 210 kPa on 8 November 1974.

Soil samples for bioassay of herbicide residues were obtained from each plot at monthly intervals from the date of spraying until the end of the cropping season (for 6 months). All samples were collected to a depth of 10 cm with a 7 cm diameter sampling tube. The bioassay species used for measuring the herbicidal activity were turnips (*Brassica rapa* cv 'Green Globe') for atrazine and German millet (*Setaria italica*) for alachlor and linuron. All samples were bioassayed in a glasshouse using the procedure described for trifluralin by Rahman and Cox (1975).

The amount of rainfall/month for the 6 months following the date of herbicide application was 51, 126, 147, 21, 116, and 90 mm.

RESULTS AND DISCUSSION

A series of 'standards' established for each herbicide by employing a range of dosages indicated that the minimum detectable concentration (the concentration which caused a significant reduction in the dry shoot weights) was 0.1 ppmw for atrazine, 0.3 ppmw for alachlor, and 0.5 ppmw for linuron.

Alachlor

Assays of soil treated with alachlor showed that the 1 kg/ha rate dissipated below phytotoxic levels in 1 - 2 months, the 2 kg/ha in 2 - 3 months and the 4 kg/ha in about 3 months in all the trial sites (Table 2). The rate of 8 kg/ha did not show any residual toxicity after 4 months in sites 2 and 3 and after 5 months in site 1, the lowest organic matter soil.

TABLE 2: RESIDUAL ACTIVITY OF ALACHLOR IN SOIL SAMPLES COLLECTED AT MONTHLY INTERVALS

Alachlor (kg/ha)	*Site*	*DM of German millet as % of Control Months after application**					
		1	*2*	*3*	*4*	*5*	*6*
1	1	64					
	2						
	3						
2	1	55	70				
	2	62					
	3	77					
4	1	47	64				
	2	54	73				
	3	68	76				
8	1	15	32	53	69		
	2	23	50	62			
	3	39	47	71			

* Figures in this table are all significantly different from their respective controls (= 100), $P < 0.05$. Blank spaces indicate that no significant differences were recorded in that month.

Herbicidal injury, as reflected by the morphological aberrations that occurred in German millet plants growing in treated soil, was much more severe than the reduction in dry weight. Generally some morphological aberrations could be noticed for at least 1 month after significant reductions in dry matter ceased to occur from residues of alachlor. However, in such cases the seedlings recovered within 2 weeks and normal plant growth (and dry matter) was produced afterwards. In some instances the residual concentration resulting in slight morphological aberrations stimulated plant growth as shown by increased dry weights and plant heights.

Linuron

Bioassay data on the persistence of linuron in Table 3 show that the 1 kg/ha of this herbicide fell below the level of detection in about 2 months and 2 kg/ha in 3 - 4 months. The 4 kg/ha rate did not disappear until the fifth month in sites 1 and 2 and until the fourth month in site 3 which had the highest organic matter content. However, the minimum detectable concentration of linuron in this study was rather high, viz. 0.5 ppmw, which may prove toxic to some species and would therefore warrant one additional month's wait over the time given in Table 3 for the disappearance of a given rate of herbicide below phytotoxic levels. Willow weed (*Polygonum persicaria*) which is slightly more susceptible to linuron (minimum detectable concentration 0.4 ppmw) was also used for bioassay of this herbicide but consistent results could not be obtained due to the lack of uniform germination and growth of this species.

Data in Table 3 suggest that the initial reduction in the residual activity of linuron was faster than its subsequent disappearance. Thus it seems that the half life of linuron may be fairly short but the disappearance below phytotoxic levels (especially from higher rates) could be much longer.

TABLE 3: RESIDUAL ACTIVITY OF LINURON IN SOIL SAMPLES COLLECTED AT MONTHLY INTERVALS

		DM of German millet as % of Control					
		*Months after application**					
Linuron (kg/ha)	*Site*	*1*	*2*	*3*	*4*	*5*	*6*
1	1	63					
	2	71					
	3	77					
2	1	52	65	76			
	2	56	73				
	3	64	74				
4	1	37	46	51	66	81	
	2	39	48	59	73		
	3	43	52	70			

* Figures in this table are all significantly different from their respective controls (= 100), $P < 0.05$. Blank spaces indicate that no significant differences were recorded in that month.

Atrazine

At an application rate of 0.5 kg/ha atrazine showed no residual activity after 3 months in any site and residues from 1 kg/ha fell below the level of detection after 5 months in site 1 and after 4 months in sites 2 and 3 (Table 4). At 2 kg/ha atrazine showed some residual activity 6 months after the initial application in site 1 but the residues

had disappeared by the sixth month in two high organic matter soils. Thus although the sensitivity of bioassay species to atrazine was higher than either alachlor or linuron, at similar rates of application atrazine showed longer persistence than these two herbicides.

As was the case with linuron the initial dissipation of atrazine appeared to be faster than its subsequent disappearance in all the sites, although not to the same extent as that of linuron.

TABLE 4: RESIDUAL ACTIVITY OF ATRAZINE IN SOIL SAMPLES COLLECTED AT MONTHLY INTERVALS

		*Months after application**					
		DM of Turnips as % of Control					
Atrazine (kg/ha)	*Site*	*1*	*2*	*3*	*4*	*5*	*6*
0.5	1	0	33				
	2	0	50				
	3	0	73				
1.0	1	0	18	51	64		
	2	0	41	63			
	3	0	36	75			
2.0	1	0	0	23	36	43	73
	2	0	0	31	53	74	
	3	0	0	41	62	78	

* Figures in this table are all significantly different from their respective controls (= 100), $P < 0.05$. Blank spaces indicate that no significant differences were recorded in that month.

Effect of organic matter

The organic matter content of the soil affected the residual activity of all three herbicides as the persistence in most cases (especially at higher rates) was up to a month longer in site 1 (which had the lowest organic matter level) than sites 2 and 3. However, this does not necessarily suggest a greater amount of herbicide residues in site 1 since higher rates of herbicides would be required to produce a specified growth reduction in sites 2 and 3 compared to site 1 due to the adsorption of large quantities of herbicides by the high organic matter soils. In fact some workers have reported increasing amounts of herbicide residues as the soil organic matter level was increased (McCormick and Hiltbold 1966; Moyer *et al* 1972). However, the total amount is not as important as the biologically-active amount which would determine whether or not a sensitive crop could follow in the crop rotation.

Results from this work should be regarded as preliminary only since these data are from only one soil type and under one set of climatic conditions. Nevertheless, these results are in agreement with the earlier findings of Beestman and Deming (1974) and Rahman *et al* (1976). In particular these data confirm the conclusions of Rahman *et al* (1975) that normal application rates of alachlor and linuron would not persist in soil in concentrations large enough to damage the following crop. Atrazine, once again, showed small residual activity in the low organic matter soil from a rate of 2 kg/ha but this would probably be diluted and dissipated after cultivation to a non toxic level. Further work is in progress with atrazine.

ACKNOWLEDGEMENTS

Thanks are due to J. M. Whitham for technical assistance, to C. B. Dyson for statistical analyses, to P. F. Noble for mechanical analyses of soil, and to Ruakura Soil Testing Laboratory for all other soil analyses.

REFERENCES

Beestman, G. B., and Deming, J. M., 1974. Dissipation of acetanilide herbicides from soils. *Agron. J.*, 66 : 308 - 11.

McCormick, L. L., and Hiltbold, A. E., 1966. Microbial decomposition of atrazine and diuron in soil. *Weeds*, 14 : 77 - 82.

Moyer, J. R., Hance, R. J., and McKone, C. E., 1972. The effect of adsorbents on the rate of degradation of herbicides incubated with soil. *Soil Biol. Biochem.*, 4 : 307 - 311.

Rahman, A., Burney, B., Whitham, J. M., and Manson, B. E., 1976. A comparison of the activity of herbicides in peat and mineral soils. *N.Z. J. Exp. Agric.* 4 : 79 - 84.

Rahman, A., and Cox, T. I., 1975. Bioassay techniques for the determination of herbicide residues. *Proc. 28th N.Z. Weed and Pest Control Conf.:* 96 - 100.

Rahman, A., Manson, B. E., Burney, B., and Whitham, J. M., 1975. Residual activity of atrazine, alachlor and linuron under different soil and climatic conditions. *Proc. 28th N.Z. Weed and Pest Control Conf.:* 104 - 108.