Crop Weeds

ATRAZINE RESIDUES IN THE GISBORNE PLAINS AND WAIKATO REGIONS

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Summary

Residual activity of atrazine from rates between 1 and 4 kg/ha was studied in the two main maize growing districts using Hamilton silt loam and Matawhero heavy silt loam soils. The top 0-2.5 cm showed higher residues than 2.5-5 or 5-7.5 cm depths at all sampling dates. By the end of May rates up to 2 kg/ha had dissipated below detectable levels in the Hamilton site while the Matawhero soil still contained phytotoxic residues from 1 kg/ha atrazine. Autumn cultivation further reduced the residue levels and dissipation continued during winter months. Turnips and Italian ryegrass sown in spring exhibited no residual toxicity in the Matawhero soil from rates up to 2 kg/ha or in Hamilton soil from rates up to 4 kg/ha.

INTRODUCTION

Maize has been the predominant agricultural crop on the Gisborne Plains for many years and atrazine in combination with other chemicals or cultivation has been used for successful weed control. Occasionally there have been reports of residual toxicity of this herbicide to some susceptible crops following in the rotation. In a maize rotation study at the Manutuke Research Station injury to soya beans was noted when preceded by a maize crop treated with recommended rates of atrazine (Douglas *et al* 1972). On the other hand Rahman *et al* (1975; 1976) concluded from a number of field trials in the Waikato area that it was doubtful if atrazine residues from rates of up to 2 kg/ha would be damaging to susceptible crops which followed in rotation. This led to a detailed study on the residual activity of atrazine in the Gisborne area, results of which are reported here. A trial was conducted simultaneously in the Waikato to compare the residual toxicity of the herbicide in the two areas and to identify the factors responsible for differences in its persistence between the two regions.

MATERIALS AND METHODS

Two identical field trials, one on Matawhero heavy silt loam soil at the Manutuke Research Station near Gisborne and the other on Hamilton silt loam soil at the Rukuhia Research Station near Hamilton, were started in 1975. An effort was made to obtain trial sites with approximately equal levels of organic matter. Some physical and chemical properties of the top 10 cm of two soils are listed in Table 1. Techniques for determining these properties have been outlined previously (Rahman 1977).

TABLE 1: Some soil properties* and rainfall records for the trial sites

Soil Type	Organic matter		Sand	Silt	Clay	C.E.C.	pH	Field capacity	Bulk density
	(%)	(t/ha)	(%)	(%)	(%)	(me./100g)		(%)	(g/cc)
Hamilton	7.1	56.8	28	36	31	25.2	5.9	34.1	0.80
Matawhero	5.2	52.5	14	47	35	21.3	6.0	33.2	1.01

	Rainfall (mm) Months after herbicide application								
	Up to 1	1-2	2-3	3-4	4-5	5-6	6-8	8-10	10-12
Hamilton	96	30	179	91	44	77	264	356	275
Matawhero	81	14	196	54	36	110	165	138	302

* Measured in top 10 cm.

Five rates of atrazine were surface applied as pre-emergence treatments in a spray volume of 250 litres/ha at a pressure of 210 kPa. Each plot was 30 x 6 m in which six rows of maize cv 'De Kalb XL 45' were planted 75 cm apart in late October. Treatments were arranged in a randomised block design with four replications. Soil samples for bioassay of atrazine residues were collected at fortnightly intervals from the date of spraying. Initially samples were collected from two depths viz. 0-2.5 and 2.5-5 cm but an additional sampling depth of 5-7.5 cm was included when leaching moved detectable amounts of herbicide into deeper layers.

After harvesting of maize in late May, 1976, the plots were ploughed once and soil samples were collected at monthly intervals from 0-10 cm depth thereafter. Trial areas were again cultivated (discing and harrowing) in spring and one third of each plot was seeded in separate strips of turnips (*Brassica rapa* cv 'Green Globe') and Italian ryegrass (*Lolium multiflorum* cv 'Grasslands Paroa') in November, 1976. These two indicator species were evaluated for injury symptoms at regular intervals and 1 m^2 samples were harvested in January for dry matter yields.

Soil samples were bioassayed in a glasshouse using the procedure described by Rahman and Cox (1975). Turnips and oats (*Avena sativa* cv 'Mapua') were employed as the test species.

RESULTS AND DISCUSSION

Results from 'standards' established with the two test species are given in Table 2. The phytotoxicity of atrazine from all rates was higher in the Matawhero soil than that of Hamilton soil and it was possible to detect lower residues in the Matawhero soil with either bioassay species. Turnips were slightly more sensitive to atrazine

than oats but both species gave comparable bioassay results throughout the study. Turnips did not grow satisfactorily in some parts of the year and hence their dry matter yields could not be used for accurate comparisons between all the samplings. Data reported here are therefore all based on the oat bioassay.

TABLE 2: Effect of atrazine on dry shoot weight of bioassay species in the glasshouse (data expressed as % of control)

Atrazine	Turnips		Oats	
ppmw	H*	M*	H	M
0	100 a	100 a	100 a	100 a
0.10	89 a	72 b	102 a	101 a
0.15	77 ab	68 b	97 a	112 a
0.20	63 b	45 c	81 ab	74 b
0.25	38 c	21 d	68 b	55 c
0.30	19 d	12 de	48 c	32 d
0.35	16 d	7 e	26 d	12 e
0.40	3 e	0	21 d	2 e
0.50	0	0	8 e	0

H — Hamilton silt loam; M — Matawhero heavy silt loam.

Bioassay results on residual activity of atrazine at different depths from the time of application until the autumn cultivation in May are given in Table 3. Residues were higher in the top 2.5 cm of the soil compared to the two lower depths at all sampling dates. In both trials atrazine rates over 1 kg/ha had moved into 2.5-5 cm layer by the first sampling (two weeks after application). Residual activity in two lower depths kept fluctuating probably due to downward movement of additional herbicide with each heavy precipitation. Persistence of atrazine at each depth was higher in the Matawhero soil than the Hamilton soil for all sampling dates. By the end of May, before the autumn cultivation was carried out, residues from rates of up to 2 kg/ha had dissipated below detectable levels in the Hamilton soil whereas the Matawhero soil contained phytotoxic residues from the lowest rate of 1 kg/ha.

Table 4 gives residual toxicity of atrazine in the top 10 cm of soil from 3 months after spraying until the spring cultivation in October. Bioassay data from 0-10 cm depth before the autumn cultivation confirmed the findings from three depths (Table 3) in that rates up to 2 kg/ha had no phytotoxic residues in the Hamilton soil while all rates showed detectable activity in the Matawhero soil. Autumn cultivation reduced the residue levels considerably and dissipation of atrazine continued during winter months. Samples collected in late October showed activity only from the 4 kg/ha rate in the Hamilton soil and from 3 and 4 kg/ha in the Matawhero soil.

Turnips and Italian ryegrass sown in the treated plots after spring cultivation exhibited no injury symptoms or yield reductions in the Hamilton trial. However, visual injury as well as yield reductions of 29% and 56% compared to the untreated control were recorded in

TABLE 3: Residual activity of atrazine in soil samples collected from different depths (DM of oats as % of control = 100)

Months after application	Atrazine (kg/ha)* 1 H	1 M	1.5 H	1.5 M	2 H	2 M	3 H	3 M	4 H	4 M
Sampling depth 0-2.5 cm										
1	0	0	0	0	0	0	0	0	0	0
2	34	7	13	0	4	0	0	0	0	0
3	72	11	41	3	5	0	0	0	0	0
4	–	19	68	10	18	0	0	0	0	0
5	–	36	–	19	42	6	12	0	0	0
6	–	51	–	28	68	12	14	0	11	0
7	–	62	–	47	–	31	29	0	21	0
Sampling depth 2.5-5 cm										
1	74	63	54	49	39	38	11	4	0	0
2	65	70	59	55	36	17	17	11	0	0
3	70	38	62	29	44	5	9	3	4	0
4	–	44	71	33	66	12	18	0	11	0
5	–	58	–	49	70	32	24	10	20	4
6	–	64	–	52	73	44	27	14	24	8
7	–	73	–	62	–	46	36	21	34	11
Sampling depth 5-7.5 cm										
3	73	59	61	44	62	22	37	0	42	0
4	–	68	–	58	74	39	52	22	49	4
5	–	65	–	64	77	51	63	29	54	11
6	–	71	–	69	–	62	67	34	62	23
7	–	–	–	77	–	71	–	43	73	35

* Figures in this table are all significantly different from their respective controls, $P<0.05$, pooled SE ± 5.6 – indicates that no significant differences were recorded in that month.

case of turnips from residues of 3 and 4 kg/ha treatments respectively in the Matawhero soil. Ryegrass was damaged only in plots treated with 4 kg/ha which produced 28% less yield than the control.

The above results clearly show that the residual activity of atrazine from any given rate of application was higher in the Matawhero soil than in Hamilton soil. No doubt the initial phytotoxicity of atrazine was higher in the Matawhero soil (Table 2) and thus comparable residues would be expected to cause greater yield reductions in the yield of bioassay species in Matawhero soil than the Hamilton trial. Nevertheless, the differences in relative dry matters reported in Tables 3 and 4 between the two sites are too great to be explained by differences in the initial activity. Although long term average yearly rainfall is higher at Rukuhia (1222 mm) than at Manutuke (958 mm), significant differences in precipitation were recorded mainly during the winter months only between two trial sites. The total

TABLE 4: Residual activity of atrazine in soil samples collected from 0-10 cm depths (DM of oats as % of control = 100)

Months after application	Atrazine (kg/ha)*									
	1		1.5		2		3		4	
	H	M	H	M	H	M	H	M	H	M
3	71	44	57	21	29	0	14	0	0	0
6	–	58	–	41	74	37	54	21	36	17
7+	–	68	–	55	–	35	65	24	49	23
7++	–	–	–	72	–	47	73	40	58	37
8	–	–	–	–	–	55	–	44	63	39
9	–	–	–	–	–	68	–	55	60	44
10	–	–	–	–	–	–	–	67	71	52
11	–	–	–	–	–	–	–	71	74	58

* Figures in this table are all significantly different from their respective controls, $P<0.05$, pooled SE $\pm$ 6.4. – indicates that no significant differences were recorded in that month.

+,++ Before and after the autumn cultivation respectively.

rainfall at each site during the first six months of the trials differed by only 26 mm (Table 1) while marked differences in the persistence of atrazine were noted between the sites during these months. Thus the climatic variations could not be solely responsible for differences in atrazine residues.

The amounts of two main soil components involved in the adsorption of atrazine (viz. organic matter and clay) do not differ enough between the two soils (Table 1) to account for the wide differences in the herbicides's persistence. It is possible that the quality of these adsorbents may bear some responsibility. The Matawhero soil is developed from alluvial sediments and contains expanding lattice type clays, mainly montmorillonite and some illite and vermeculite (Pullar 1962). The Hamilton soil is strongly weathered and is derived mainly from rhyolitic material deposited on volcanic ash. It contains mainly halloysite and some kaolinite clay minerals (N.Z. Soil Bureau 1968). The type of clay mineral has been shown to influence the adsorption of atrazine by the soil (Harrison *et al* 1976; Weber 1970).

Because of the distinctly different parent materials and continuous cultivation and compaction of the Matawhero soil there are large differences in the physical properties of the two soils which probably have greater bearing on the persistence of atrazine than the differences in chemical properties. The Matawhero soil has a lower sand content and much higher bulk density than the Hamilton soil (Table 1) both of which lead to decreased movement of atrazine in the soil (Bailey and White 1970). Further work would be needed to determine which soil properties may be responsible for greater residual activity in Matawhero soil than that in the Hamilton soil.

Results of this study show that the present recommended rate of atrazine in maize (1.6 kg/ha) should pose no problem to suscep-

tible crops in rotation the following spring in the two major maize growing areas of the country. This also applies to sensitive crops following maize in autumn after thorough cultivation in the Hamilton region but special attention would be needed in selecting a follow up crop for autumn in the Gisborne region. These results are in agreement with the findings of Naish and Forgie (1976). Further studies are in progress to assess whether these results would be applicable to cases where atrazine has been used for more than one growing season in the same field.

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