ATRAZINE RESIDUES UNDER COMMERCIAL MAIZE CROPPING CONDITIONS

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Summary

A bioassay method was used to assess the persistence of atrazine in maize (*Zea mays*) cropped soils. Soils from 24 maize fields were sampled immediately after harvest and those showing phytotoxic residues were sampled again following cultivation after winter fallow. Although atrazine was detected in 64% of sites sampled in the autumn, 6 months after post-emergence application of 1.8 kg/ha the previous spring, residues persisting after cultivation 9 months after original herbicide treatment were not sufficient to damage susceptible species in rotation.

INTRODUCTION

The success of maize (*Zea mays*) in New Zealand has been assisted by the availability of effective herbicides, in particular atrazine. With the change in weed spectrum from predominantly broadleaf species to annual summer germinating grasses (Matthews 1971), and a greater number of crops on high organic matter soils there has been a tendency to use higher dosages of atrazine either applied alone or in combination with grass herbicides. While residues of atrazine are of minor importance where maize crops are grown in succeeding years, they may result in damage if susceptible crops follow in rotation.

Rahman *et al* (1975) concluded from a number of field trials that it was doubtful if atrazine residues from 2 kg/ha rates would be damaging to susceptible species when followed in rotation. This paper reports a study which assessed atrazine residues under commercial usage following existing label recommendations with regard to dosage, post-crop cultivation, and crop rotation, in 24 maize crops in Gisborne, Hawkes Bay, and Taranaki in the 1974 - 75 season. Residues in soil from these sites were determined by a bioassay technique, though a chemical method of analysis is described and the sensitivity of the two methods compared.

METHODS

Soil sampling

Twenty-four fields of maize (Gisborne 5, Hawkes Bay 14, and Taranaki 5), 17 of which had received at least 1.8 kg per treated ha atrazine either alone or in combination with alachlor were chosen for sampling. Bulked samples of 1 - 2 kg of soil were obtained by random collection of at least 60 soil cores, 25 mm diameter x 75 mm deep from each site following maize harvest and (with one exception) before cultivation. Where phytotoxic residues were found in autumn, sites were re-sampled following spring ploughing. Atrazine-free soil samples as available were obtained from the same location for comparison with treated soils.

Bioassays

The bioassay technique used was similar to that of Rahman and Cox (1975) and employed turnips (*Brassica rapa* cv 'York Globe').

'Standard' plant growth curves were established for six different soils representative of the three areas, by employing a range of atrazine concentrations between 0.0625 ppmw to 2 ppmw. Because the survey assessed presence or absence of phytotoxic residues of atrazine, a simple visual rating system (VR) was used rather than the more laborious measurement of shoot dry weight. Ratings were done by two independent observers 28 days after sowing, and were the means of four replicates where

0 = no effect
1 = slight chlorosis with plants returning to normal colour
2 = moderate to severe chlorosis and leaf burn
3 = up to 50% stand reduction and/or suppression and chlorosis
4 = 50 - 90% stand reduction and/or suppression
5 = 100% dieback of all germinating seedlings.

Chemical analysis

Atrazine in soil was determined by gas liquid chromatography (GLC) following extraction and clean up using the method of Mattson *et al* (1970). This employed a 10% water-acetonitrile solvent system; refluxing the soil/solvent mixture for one hour and clean-up using an alumina column. The resultant extract was then examined by alkali flame ionisation GLC for calculation of the amount of atrazine in the original soil sample.

RESULTS AND DISCUSSION

Comparison of assay techniques

Table 1 compares biological and chemical assay of six samples of Egmont volcanic sandy loam previously 'spiked' with atrazine at dosages of from 0.0625 - 2 ppmw. The soil organic matter content was 11%.

TABLE 1: BIOLOGICAL AND CHEMICAL ASSAYS OF ATRAZINE IN EGMONT VOLCANIC SANDY LOAM SOIL

Sample	*Bioassay visual rating*	*Atrazine concentration (ppmw)*		
		Actual	*Bioassay*	*GLC analysis*
A	0	0.0625	0	0.06
B	0	0.125	0	0.13
C	0.3	0.25	0.28	0.21
D	1.4	0.5	0.45	0.51
E	3.4	1.0	1.0	1.10
F	4.9	2.0	1.91	1.99

The data show good agreement between the two methods of assaying atrazine within the range of 0.25 - 2 ppmw. The sensitivity of chemical analysis was greater than the bioassay technique used though the correlation between the two methods was better than in a number of similar comparisons reviewed by Behrens (1970). Both Behrens (1970) and Rahman and Cox (1975) stressed chemical methods as sometimes giving misleading results if their extraction techniques remove residues which are normally too firmly adsorbed on soil to affect plants. For this reason the bioassay method was used to assay atrazine residues in soils of the maize fields surveyed.

Bioassays

Table 2 summarises soil types, application rates and bioassay results from the 24 fields sampled.

TABLE 2: SOILS, TREATMENTS AND BIOASSAY DATA FROM MAIZE FIELDS SAMPLED

SOIL TYPE	NO. OF SITES	NO. CONSECUTIVE MAIZE CROPS	RATE ATRAZINE KG/SPRAYED HA	APPLICATION METHOD	AUTUMN SAMPLE VISUAL RATING	CULTIVATION	POST CULTIVATION VISUAL RATING
GISBORNE							
CLAY LOAM	1	8	1.8	band	2.5	plough 15 cm	1
SILT LOAM	1	2	1.8	broadcast	2.9	plough 20 cm	0**
CLAY LOAM	2	6–8	1.8–2.2	broadcast	1	—	NS
CLAY LOAM	1	1	1.8	broadcast	NS	4 x 15 cm discings	1
HASTINGS							
YGE SILT LOAM	1	3	NK	NK	5	no cultivation	3.2
YGE SILT LOAM	1	NK	4	broadcast	0	—	NS
YGE SILT LOAM	2	1–3	1.2–1.8	broadcast	0	—	NS
YGE SILT LOAM	2	3 & 4	2 & 1.8	band	1 & 3	plough 15 cm	0 & 1
ALLUVIAL SILT LOAM	2	3–8	6 in band	band	4.8–4.9	plough 25 cm	0
ALLUVIAL SILT LOAM	3	1–3	1.2–1.8	broadcast	4.8–5	plough 15–20 cm	0–1*
ALLUVIAL SILT LOAM	1	1	1.2	broadcast	0.4	—	NS
ALLUVIAL SILT LOAM	1	2	1.2	broadcast	4.9	no cultivation	0
PEAT	1	1	1.8	broadcast	0	—	NS
TARANAKI							
YBE VOLCANIC SANDY LOAM	5	1–2	0.5–2	broadcast	0	—	NS

NK = not known NS = not sampled * only 2 sites resampled ** This soil was also sampled in spring before cultivation and had VR = 2

Any soil sample showing a bioassay rating of 0 - 1 (i.e., induced slight chlorosis with no reduction of vigour) was considered to have atrazine levels low enough not to affect significantly sensitive crops following in rotation. Bioassay results indicated detectable atrazine residues from 16 sites sampled and 11 of these would have had sufficient residues to damage sensitive crops (i.e., VR $\geqq$ 1) if sown immediately after maize harvest. The latter group included 80% of all band treated areas (4 sites), 30% of all broadcast treatments (6 sites) and 1 site where the rate of atrazine and application method was unknown.

Of the 11 areas showing damaging residues, 10 were re-sampled the following spring; 8 followed spring ploughing, and the remainder had received no cultivation. From the samples taken after ploughing, atrazine was detected in the top (inverted) 75 mm profile in only 3 sites, and in amounts insufficient to reduce vigour of the bioassay plants (i.e. VR $\leqq$ 1). In three uncultivated sites resampled (shown in Table 2), initially highly-damaging residues of atrazine had decreased by a mean of 50% during the 3-month winter fallow. However, the final residue level at two sites was still sufficient to damage sensitive crops; in one of these (Gisborne silt loam) the residue has dissipated by ploughing to a depth of 20 cm.

Although 81% of the sites where atrazine was detected at the end of the cropping season had been cropped in maize consecutively for between 2 and 8 years, there was no correlation between the number of croppings and the amount of residue found at the end of the cropping season. This is in agreement with studies in North America (Austin *et al* 1968) where no evidence of accumulation or increased injury to sensitive rotational crops was found from three successive applications of atrazine.

In the bioassays there was a marked difference in the atrazine residue which produced a visual effect on the test plants grown in the different soils surveyed. For example, the residue in Egmont sandy volcanic loam soil corresponding to the lowest bioassay rating (VR = 1) was more than twice that of the silt loam soils of Hawkes Bay. This was probably related to variations in organic matter content and adsorption thereto as has been shown by Upchurch and Mason (1962), Sheets *et al* (1962) and Rahman *et al* (1975). Though differences in persistence of atrazine were also observed in soils from different regions, data available was insufficient to identify the factors responsible.

CONCLUSION

Residues of atrazine were found in a majority of maize sites when the undisturbed soil was sampled immediately after harvest, which could have affected sensitive crops such as short rotation ryegrass (*Lolium multiflorum*) if direct-drilled into the crop stubble. However, these residues were not present when fields were re-sampled in the spring after land was thoroughly cultivated, indicating that there is little likelihood of damage to susceptible crops following atrazine use according to label recommendations for control of weeds in maize. Special care would be needed in the use of atrazine in a relatively short rotation crop such as sweetcorn.

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