FIELD PERSISTENCE OF SOME MAIZE HERBICIDES IN TWO SOILS

A. RAHMAN and T.K. JAMES

*AgResearch, Ruakura Agricultural Research Centre,
Private Bag 3123, Hamilton*

SUMMARY

To study the persistence of five maize herbicides in two field trials (each representing a different soil type), soil samples were collected from the top 10 cm depth at monthly intervals for glasshouse bioassays. Simultaneously, dose-response curves were established in the glasshouse for the two soil types. The emulsifiable concentrate (EC) formulation of alachlor showed more biological activity than a micro-encapsulated (ME) formulation. Biologically active residues of the ME formulation did not persist in the field as long as that reported previously for the EC formulation. Phytotoxic residues of metolachlor and acetochlor were detected for 3 - 4 months and those of dimethenamid for 2 - 3 months depending on the soil type. Residual activity of S-23121 lasted for less than 1 month.

Keywords: herbicide persistence, acetochlor, alachlor, metolachlor, dimethenamid

INTRODUCTION

The use of a selective pre-emergence herbicide for control of germinating grasses and some broadleaf weeds is a recommended practice for maize crops in New Zealand (Rahman 1985). The activity and persistence of these herbicides is greatly influenced by soil characteristics, particularly the organic matter and clay content of the soil (Peter and Weber 1985; Rahman 1988). Since the persistence of herbicides used for control of weeds in maize was last reported at this conference (Rahman *et al.* 1978), some new herbicides have been developed. Dimethenamid, a chloroacetamide herbicide with good activity against many annual grasses and broadleaf weeds (Harr *et al.* 1991) has been evaluated in New Zealand (Rahman and James 1992) and recently registered for use in maize. Acetochlor is a new acetanilide herbicide similar to alachlor with more activity on broadleaf weeds (Elker *et al.* 1993; Weber and Peter 1982), which has also been recently registered in New Zealand, although no research results have been published here as yet. S-23121 is a phthalimide herbicide with activity against a wide range of broadleaf weeds including atrazine-resistant fathen (*Chenopodium album*) and with good selectivity in wheat and maize (Hamada *et al.* 1989). There is no published information on this herbicide in New Zealand and it is not yet registered here.

All the pre-emergence herbicides used for weed control in maize act primarily through the soil and hence their behaviour in New Zealand soils is important. The present study was designed to compare the residual activity of these herbicides under field conditions in two Waikato soil types commonly used for maize production.

MATERIALS AND METHODS

Establishment of standards in the glasshouse

As a first step, glasshouse experiments were conducted to establish standard curves of the activity of known concentrations of the herbicides (Table 1) in two soils, viz. Horotiu sandy loam (7.3% organic C, 61% sand, 16% clay, pH 5.9) and Hamilton clay loam (2.4% organic C, 57% sand, 27% clay, pH 6.5). The bioassay species used were: foxtail millet (*Setaria italica*) and oats (*Avena sativa*) for alachlor ME (Lasso

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Microtech 480 g ai/litre), alachlor EC (Shell Alachlor 480 g ai/litre), metolachlor (Dual 960 g ai/litre) and acetochlor (Roustabout 840 g ai/litre); Italian ryegrass (*Lolium multiflorum*) and oats for dimethenamid (Frontier 900 g ai/litre); and radish (*Raphanus sativus*) and subterranean clover (*Trifolium subterraneum*) for S-23121 (100 g ai/litre suspension concentrate).

A range of herbicide concentrations (between 0.01 and 10 mg/kg by weight of dry soil) used to establish the standard curves were individually made up in volumetric flasks and added to weighed amounts of air-dry soil. This soil was thoroughly mixed by shaking it in a polythene bag, left overnight to equilibrate, and then used for potting out the test species. Fifteen seeds of each test species (10 for oats) were planted at 3 mm depth in 10 cm diameter plastic pots which were then placed in the glasshouse in a randomised block layout with four replicates. All pots were sub-irrigated to maintain the soil between 80% and 100% field capacity. The plants were grown in the glasshouse for 4 - 5 weeks before assessment for damage and then harvested for dry matter yields. The dose-response relationship was determined from the shoot dry weight data. The standards were repeated at approximately 6-weekly intervals between 28.8.92 and 4.3.93, with soil from the same site but collected fresh for each experiment, for the duration of the field trials.

On three occasions in the latter part of the study standards for two different formulations of alachlor viz. emulsifiable concentrate (EC) and micro-encapsulated (ME) flowable, were directly compared to evaluate their relative activities in both soils.

Persistence of the herbicides in field trials

One field trial was conducted on each of the two soil types mentioned above. Both trials were of a randomised block design with four replicates and individual plot size of 10 x 3 m. The herbicide treatments (Tables 1 and 2) were applied with a CO₂ powered precision sprayer in 300 litres/ha of water at 200 kPa. The maize cv. Pioneer 3475 was planted with a Nodet Gougis precision seeder at 76000 seeds/ha and 75 cm row spacing. Trial 1 (Horotiu sandy loam soil) was planted on 20 October 1992 and the treatments were applied on 27 October 1992 when air temperature was 15°C, the sky was overcast and the soil surface was moist. Trial 2 (Hamilton clay loam soil) was planted on 28 October 1992 and treatments were applied the following day when the air temperature was 16°C, the sky was sunny and the soil surface was dry. Monthly rainfall at both sites for November to February was 80, 139, 33 and 42 mm.

Soil samples for determination of herbicide residues were collected in the first week after application and approximately monthly thereafter. Five 7.5 cm diameter soil cores were collected from each plot to a depth of 10 cm. These were bulked together before being brought to the glasshouse where they were thoroughly mixed and used for planting one pot of each of the bioassay species. The bioassays were planted, grown and assessed in the same way as the standards described above.

RESULTS AND DISCUSSION

Establishment of standards in the glasshouse

Of the bioassay species evaluated the most sensitive were; foxtail millet for alachlor, metolachlor and acetochlor; Italian ryegrass for dimethenamid; and radish for S-23121. Herbicidal injury, as reflected by morphological aberrations of foxtail millet plants (kinking or twisting of the leaves) growing in the soil treated with the acetanilide herbicides, was much more severe than the reduction in dry weight indicated. At low concentrations the visual damage was confined to the first leaf only and in such cases the seedlings recovered in 2 - 3 weeks and normal plant growth (and dry matter) was produced afterwards.

The activities of the five herbicides on the bioassay species are presented in Figures 1A and 1B for the Horotiu sandy loam and Hamilton clay loam soils respectively. In all the experiments metolachlor was less active in the Horotiu sandy loam soil than in the Hamilton clay loam soil, probably because the latter soil has a much higher organic C content (cf. Weber and Peter 1982; Peter and Weber 1985). The

magnitude of difference in the biological activities of acetochlor, dimethenamid and S-23121 between the two soils was much smaller (Figures 1 and 2) and this supports our earlier findings (Rahman and James 1992). The phytotoxicity of these three herbicides through the soil was fairly similar, despite different bioassay species being used to measure the activity.

In the initial experiments when standards were being established, the concentrations used for alachlor were taken from Rahman *et al.* (1978) for the same soil types. However, these concentrations showed very little activity in the present study (Fig. 1). These differences may have been due to the formulation of the alachlor because in the present study we used an ME formulation while Rahman *et al.* (1978) used an EC formulation. To test this hypothesis the two formulations were evaluated side by side in later glasshouse experiments. The results of these studies are presented in Figure 2 and clearly show that the ME formulation was considerably less active than the EC formulation in both soils. The figures for the EC formulation of alachlor in the present study are more consistent with those reported earlier by Rahman *et al.* (1978).

FIGURE 1A: Horotiu sandy loam soil.

FIGURE 1B: Hamilton clay loam soil.

Figure 1: Activity of five herbicides on bioassay species in two different soils.

Figure 2: Effect of two formulations of alachlor on foxtail millet in two different soils.

Persistence of herbicides in the field

All the herbicides (except dimethenamid which was only used at one site) were slightly more persistent under field conditions in the Hamilton clay loam soil than in the Horotiu sandy loam soil (Tables 1 and 2). At normal usage rates metolachlor and acetochlor persisted for 3 months in the Horotiu sandy loam soil and 4 months in the Hamilton clay loam soil, while alachlor (ME formulation) persisted for only about 2 months in both soils. Dimethenamid persisted for up to 3 months in the Hamilton clay loam soil. In contrast S-23121, used within the range of the rates required for effective control of broadleaf weeds (Hamada *et al.* 1989), showed very little persistence in this study (less than 1 month).

TABLE 1: Dry matter production, as percent of untreated, of bioassay species grown in Horotiu sandy loam soil sampled at various intervals after treatment on 27.10.92.

Herbicide	Rate	2.11.92	Dry Matter (% of untreated) ¹			
	(kg ai/ha)		7.12.92	6.1.93	5.2.93	10.3.93
Foxtail millet						
acetochlor	2.52	0	62	72	90	94
acetochlor	5.04	0	50	68	77	101
alachlor	3.36	24	76	105	98	109
metolachlor	3.17	0	43	35	88	97
Radish						
S-23121	0.05	97	104	108	95	
S-23121	0.10	84	102	96	110	

¹ Figures in italics are significantly different from untreated control ($P < 0.05$).

The persistence of the ME formulation of alachlor in these trials was less than the 3 months reported by Rahman *et al.* (1978) for the EC formulation. Capri *et al.* (1994) have shown that, based on chemical analyses (total residues), the half-life ($t_{1/2}$) in the soil of an ME formulation of alachlor was considerably greater than a liquid (EC) formulation. It appears therefore, that although the ME formulation has a longer half-life in the soil, this is at the expense of the plant available active ingredient. In the present study, after 2 months, the herbicide was not present in sufficient biologically active concentrations to affect the bioassay species after it had been mixed throughout the 10 cm soil depth sampled. In order to maintain its activity on weeds the less active ME formulation of alachlor must remain concentrated in the top few centimetres of the soil and not leach down the soil profile. This could be tested in future studies by collecting samples from different depths and measuring the residual activity.

The difference in persistence of acetochlor and metolachlor between the two field trials reflects the large differences in soil organic C content. Both these herbicides are adsorbed moderately by the soil organic matter (Weber and Peter 1982) and herbicide persistence and mobility is inversely related to soil adsorption. Dimethenamid was less persistent than acetochlor and metolachlor and the length of its residual activity was similar to that reported by Rahman and James (1992).

The results of this study show that the pre-emergence herbicides available at present for weed control in maize in New Zealand have moderate persistence in the soil. Generally, this is long enough to provide weed control for the 10 to 15 weeks required for the crop canopy to fully develop and the crop to compete more strongly with weeds. However, the residual activity only persists for brief periods and should not affect subsequent crops which may be planted immediately after the maize crop. The length of persistence was affected by soil characteristics and also varied between two formulations in the case of alachlor.

TABLE 2: Dry matter production, as percent of untreated, of bioassay species grown in Hamilton clay loam soil sampled at various intervals after treatment on 29.10.92.

Herbicide	Rate	2.11.92	Dry Matter (% of untreated) ¹			
	(kg ai/ha)		8.12.92	6.1.93	5.2.93	9.3.93
Foxtail millet						
acetochlor	2.52	0	40	60	83	104
acetochlor	5.04	0	13	59	68	88
alachlor	3.36	4	61	93	100	10
metolachlor	3.17	0	15	46	65	93
Radish						
S-23121	0.05	93	90	107	108	
S-23121	0.10	71	98	116	103	
S-23121	0.15	71	100	117	94	
Italian ryegrass						
dimethenamid	1.35	3	57	90	95	102
dimethenamid	1.80	2	38	78	83	98

¹Figures in italics are significantly different from untreated control ($P < 0.05$). Data are presented only for the most susceptible species for each herbicide.

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