RESIDUAL ACTIVITY OF SOME NEWLY DEVELOPED POST-EMERGENCE HERBICIDES FOR GRASS WEEDS

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SUMMARY

The persistence and movement of six post-emergence herbicides for control of grass weeds was investigated in two soil types over two growing seasons. Soil samples from 0-10 cm depth were collected 1, 4 and 7 days after spraying and at weekly intervals thereafter and bioassayed using maize (*Zea mays* cv. 'Pioneer 3709') and annual ryegrass (*Lolium multiflorum* cv. 'Tama'). All these herbicides were found to have short residual life in the soil, with fenoxaprop-ethyl, alloxym sodium, sethoxydim and RE 36290 dissipating below detectable levels in 1 to 3 weeks, fluazifop-butyl within 6 weeks and haloxyfop in 6 to 14 weeks. Large differences in persistence of some herbicides were observed between the two soils, which appeared to be related to their biological activity in each soil. There was very little movement of any herbicide in the 10-20 cm soil depth.

INTRODUCTION

Recent discovery of several selective post-emergence herbicides capable of controlling grass weeds in broadleaf crops now provides an effective alternative to traditional pre-emergence treatments. Most of these new post-emergence herbicides have a similar mode of action, i.e., disruption and decay of meristematic tissues (Velovitch 1982), and appear to translocate to underground plant parts such as roots, rhizomes and stolons. The major activity is through foliar uptake but some soil activity has been demonstrated by most of them as pre-emergence treatments, although at much higher rates of application.

Some residual activity from post-emergence applications has been observed with many of these compounds, particularly when rainfall is adequate (Bieringer *et al* 1982; Rahman and Sanders 1982; Ready 1982; Ryder *et al* 1983). The regeneration of ryegrass in a pasture treated with some of these herbicides was slow (Rahman *et al* 1983) and soil persistence as determined by ryegrass bioassay varied from less than 6 weeks for alloxym sodium to 50 weeks for fluazifop-butyl (Richardson *et al* 1981). In our agricultural system the instances of fields growing annual broadleaf crops going into pasture are not rare. Thus information on the establishment of ryegrass following the application of these new grass weedkillers is of considerable importance.

MATERIALS AND METHODS

Four field trials were conducted on Horotiu sandy loam (14% clay, 63% sand, 10.8% organic C, 42.5% field capacity and a pH of 5.9) and Hamilton clay loam (33% clay, 31% sand, 4.9% organic C, 36.1% field capacity and a pH of 5.7) soils between 1983 and 1985.

Three rates of each of the selective grass weedkillers were sprayed in late November to mid December (in a crop of peas or onions infested with grass weeds) with a precision plot sprayer in 300 litres/ha water at 210 kPa. A white emulsifiable crop oil (BP crop oil) was mixed with alloxym sodium (Alloxol) at 4 litres/ha and with sethoxydim (Alloxol S), haloxyfop (Dowco 453) and RE 36290 at 1% v/v of spray mix. A wetting agent (Citowett) at 0.6% v/v was added to fluazifop-butyl (Fusilade). Individual plots were 2 × 10 m and treatments were arranged in a randomised block design with four replications.

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Soil samples for bioassay of herbicide activity were obtained from the 0-10 cm depth 1, 4 and 7 days after spraying and at weekly intervals thereafter from each plot. On days 7, 14 and 21 after spraying samples were also taken from the 10-20 cm depth to check the movement of herbicides in the two soils. Each sample consisted of 4-5 cores per plot using a 7 cm diameter soil sampler. All samples were bioassayed in the glasshouse using maize and annual ryegrass as the test species. A series of "standards" was established in the glasshouse for both soil types by employing a range of concentrations of each herbicide (mixed with the soil throughout the pot) and determining the effect on plant growth and dry matter weight of shoots.

RESULTS AND DISCUSSION

The concentration of each herbicide in the standards series required to produce a 50% reduction in the growth of bioassay species compared with the control (GR_{50}) is presented in Table 1. The figures show that as a test species ryegrass was more susceptible than maize to all herbicides except fluazifop-butyl which was slightly more damaging to maize plants. All the persistence data presented in the subsequent tables, therefore, are based on the ryegrass bioassay.

TABLE 1: The concentration (ppmw) of each herbicide in the standards series needed to give 50% growth reduction of bioassay species (GR_{50}).

Herbicide	Maize		Annual ryegrass	
	Horotiu sandy loam	Hamilton clay loam	Horotiu sandy loam	Hamilton clay loam
aloxymid sodium	1.80	9.50	0.22	0.49
sethoxydim	0.72	12.50	0.15	2.80
fenoxaprop-ethyl	1.48	3.10	1.38	5.20
fluazifop-butyl	0.87	0.72	0.96	0.54
haloxyfop	0.46	0.18	0.38	0.07
RE 36290	0.45	6.80	0.14	3.80

The GR_{50} figures in Table 1 also give an indication of the relative phytotoxicity of different herbicides applied through the soil. For example, in the Horotiu sandy loam soil alloxymid sodium, sethoxydim and RE 36290 showed high levels of phytotoxicity (low GR_{50} values) to ryegrass, haloxyfop was of medium level, while fluazifop-butyl and fenoxaprop-ethyl (HOE 33171) showed low phytotoxicity. This relative activity, however, varied with the soil type, the variation being quite large with some herbicides particularly sethoxydim and RE 36290. The phytotoxicity of haloxyfop and fluazifop-butyl was higher in the Hamilton clay loam than in the Horotiu sandy loam soil while the activity of all other herbicides was much lower in the Hamilton clay loam soil.

The above mentioned differences in the GR_{50} values of herbicides between two soils were reflected in the bioassay data presented in Tables 2 and 3. For example, the persistence of sethoxydim and RE 36290 in the top 10 cm of the Hamilton clay loam soil was very short (Table 3) compared to that of the Horotiu sandy loam soil (Table 2). It could be assumed that this large difference is more due to the high GR_{50} values of these two herbicides in the Hamilton clay loam rather than their shorter persistence in this soil compared to the Horotiu sandy loam soil. Smith and Hsio (1983) recorded similar losses of radioactivity of sethoxydim from a sandy loam (10% clay) and a clay loam (30% clay) soil in Saskatchewan, Canada. Persistence data with haloxyfop and fluazifop-butyl also confirm the above observation as their persistence was longer in the Hamilton clay loam (exhibiting lower GR_{50} values for these compounds) than in the Horotiu sandy loam soil.

Overall, the residual activity of all the post-emergence grass herbicides tested in this study was relatively short. This has been suggested or observed also by other workers (Bieringer *et al* 1982; Naish *et al* 1982; Ryder *et al* 1983; Smith and Hsio 1983; Stewart *et al* 1982). Based on the ryegrass bioassay data presented in Tables 2 and 3, at about the

TABLE 2: Bioassay of herbicide residues in 0-10 cm soil depth in the Horotiu sandy loam soil.

Herbicide	Rate (kg ai/ha)	Dry shoot weight of ryegrass (% of control)*							
		Days after spraying							
		1	4	7	14	21	28	42	56
alloxydim sodium	1.5	26	30	77	<i>91</i>				
	3.0	0	6	61	<i>88</i>				
sethoxydim	0.5	0	19	71	<i>87</i>				
	1.0	0	0	16	78	<i>112</i>			
	2.0	0	0	3	52	81	<i>102</i>		
fenoxaprop-ethyl	0.18	79	98						
	0.36	72	82	<i>106</i>					
	0.54	67	79	<i>100</i>					
fluzifop-butyl	0.25	75	81	<i>93</i>					
	0.50	44	64	71	76	84	<i>104</i>		
	1.00	12	32	39	52	69	80	98	
haloxyfop	0.25	41	48	66	79	<i>88</i>			
	0.50	22	37	57	67	78	84	<i>112</i>	
	1.00	0	6	24	39	59	64	78	<i>109</i>
RE 36290	0.25	8	35	67	<i>89</i>				
	0.50	6	18	34	75	<i>86</i>			
	1.00	0	0	21	65	78	<i>91</i>		

* Figures in italics are not significantly different from untreated controls (= 100), $P < 0.05$. The subsequent blank spaces also represent data not significantly different from controls.

recommended use rates persistence of fenoxaprop-ethyl was between 1 and 7 days, alloxydim sodium and sethoxydim between 7 and 21 days, RE 36290 between 4 and 21 days, fluzifop-butyl between 28 and 42 days and haloxyfop between 42 and 98 days depending on the soil type.

The very short persistence of some herbicides reported in Tables 2 and 3 does not necessarily demonstrate their rapid disappearance from the soil but rather reflects the lack of their biological activity through the soil and the low sensitivity of the test species. If more sensitive chemical assays were used, the residues of some herbicides in the soil may have been determined for a longer period. Also, in addition to the effect on shoot growth mentioned in Table 1, all herbicides caused severe root pruning of the two bioassay species, the effect being more obvious on maize plants. As pots were watered close to field capacity at all times, this root pruning did not seriously affect the growth of plants at the lower concentrations of herbicides. Under field conditions, however, where the moisture levels close to the soil surface are often low, damage from similar concentrations could be much more than that measured in the glasshouse.

The movement of these herbicides in the soil was studied by collecting samples from the 10-20 cm depth. Bioassays of the first sampling on day 7 showed no residues of alloxydim sodium or fenoxaprop-ethyl in either soil, detectable residues at the highest rate of RE 36290 only in the Horotiu sandy loam soil and of sethoxydim, fluzifop-butyl and haloxyfop in both soils (Table 4). Data for the next sampling at day 14 showed significant residues of only haloxyfop in the Hamilton clay loam soil while on day 21 no detectable residues of any herbicides were found in either soil.

In conclusion, the results presented here show that the recently developed post-emergence herbicides for the control of grass weeds tested in this study have a relatively short residual life in the soil and should pose little or no problem in the crop rotation. Haloxyfop was the only herbicide persisting in the soil for more than 6 weeks, for which

some caution may be required. There was a large difference in the persistence of some herbicides between two soils which reflected the level of their biological activity in the particular soil type.

TABLE 3: Bioassay of herbicide residues in 0-10 cm soil depth in the Hamilton clay loam soil.

Herbicide	Rate (kg ai/ha)	Dry shoot weight of ryegrass (% of control)*							
		Days after spraying							
		1	4	7	14	21	28	42	56
alloxydim sodium	1.5	53	59	84	<i>103</i>				
	3.0	35	44	73	<i>92</i>				
sethoxydim	0.5	92							
	1.0	81	<i>109</i>						
	2.0	64	72	76	<i>96</i>				
fenoxaprop-ethyl	0.18	95							
	0.36	87							
	0.54	78	<i>86</i>						
fluazifop-butyl	0.25	49	64	65	70	83	<i>106</i>		
	0.50	26	39	45	53	70	82	<i>90</i>	
	1.00	1	10	19	28	37	56	77	82
haloxyfop	0.25	8	14	12	19	32	44	53	64**
	0.50	0	0	0	4	6	15	34	47**
	1.00	0	0	0	0	0	0	4	8**
RE 36290	0.25	89							
	0.50	84	<i>102</i>						
	1.00	80	<i>88</i>						

* Figures in italics are not significantly different from untreated controls (=100), $P < 0.05$. The subsequent blank spaces also represent data not significantly different from controls.

** Figures for further samplings of Dowco 453 were — Day 70: 90, 70, 24; Day 84: —, 83, 38; Day 98: —, 95, 62; Day 112: —, —, 97,.

TABLE 4: Movement of herbicide residues in the 10-20 cm depth in two soils 7 and 14 days after spraying.

Herbicide	Rate (kg ai/ha)	Horotiu sandy loam		Hamilton clay loam	
		Day 7	Day 14	Day 7	Day 14
sethoxydim	1.0	101	95	96	102
	2.0	71*	91	84*	104
fluazifop-butyl	0.5	92	100	89	106
	1.0	81*	109	77*	98
haloxyfop	0.5	87	95	94	97
	1.0	77*	95	71*	82*
RE 36290	0.5	89	95	102	96
	1.0	74*	88	106	104

* Significantly lower than untreated controls (= 100), $P < 0.05$.

Alloxydim sodium, fenoxaprop-ethyl and the low rate of herbicides mentioned in this table had no detectable residues.

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