SOIL MOBILITY AND MOISTURE STUDIES WITH SOME GRASS HERBICIDES

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SUMMARY

Experiments were conducted in the glasshouse to study the effect of soil moisture on the activity of the grass herbicides sethoxydim, quizalofop and clethodim, and to investigate the soil mobility of these three herbicides plus haloxyfop and fluazifop-butyl. Moisture stress about the time of application significantly reduced the phytotoxicity of all three herbicides. Soil mobility of biologically active amounts of herbicides was measured in soil columns using maize (*Zea mays*) or annual ryegrass (*Lolium multiflorum*) as test species. Clethodim was the most mobile and quizalofop and haloxyfop were the least mobile of the herbicides tested. At recommended field use rates these herbicides are unlikely to move very far down the profile.

INTRODUCTION

The first members of a new family (carboxylics) of selective grass herbicides were introduced to New Zealand in the early 1980's and were investigated by several researchers (e.g. Naish *et al* 1982; Stewart *et al* 1982; Rahman *et al* 1983).

Recently two more selective grass herbicides, quizalofop and clethodim, have been tested for their efficacy and crop tolerance under local conditions (James *et al* 1988; Sanders *et al* 1988; Rahman *et al* 1988; Kerse *et al* 1989). The effect of some environmental and other factors on the fate of these herbicides is not documented for New Zealand conditions and soils. The aim of the research reported here was to study two of these factors, namely the effect of soil moisture levels on herbicide activity and the mobility of these herbicides in the soil.

The growth and development of plants and the effectiveness of herbicides are all affected by the water status of the soil. Several researchers (e.g. Bieringer *et al* 1982; Blair *et al* 1984; Rahman 1985) have shown in both glasshouse and field studies that the phytotoxicity of post-emergence grass herbicides is reduced under conditions of moisture stress about the time of spraying. The work reported here compared the activity of clethodim and quizalofop under conditions of moisture stress with that of sethoxydim which has previously been examined (Rahman 1985).

The persistence and mobility of herbicides in the soil is important in determining their efficacy as well as their potential for causing crop damage and environmental pollution. The movement down the soil profile is dependent on environmental factors such as temperature and rainfall as well as various soil factors which determine adsorption and persistence in the soil. The study reported here compared the mobility of biologically active amounts of clethodim and quizalofop in the soil with three other grass herbicides (viz fluazifop-butyl, haloxyfop and sethoxydim).

MATERIALS AND METHODS

The soil used for all the experiments was a Horotiu sandy loam with 61% sand, 19% silt, 12% clay, 9.8% organic carbon, a pH of 5.6 and a field capacity of 42.8%. The herbicides used were quizalofop (Zero), clethodim (Select) and sethoxydim (Alloxol S) in both studies with fluazifop-butyl (Fusilade) and haloxyfop (Gallant) also included in the mobility study. Maize (*Zea mays* cv Pioneer 3709) was used as the test species for all herbicides in the soil moisture studies and for quizalofop and fluazifop-butyl in the soil mobility experiments. Annual ryegrass (*Lolium multiflorum* cv Tama) was used as the test species for clethodim, sethoxydim and haloxyfop in the mobility experiments.

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Each experiment was repeated three times. In all experiments plants were grown in the glasshouse at temperatures between 22 and 30 °C during the day and above 16 °C at night. No artificial light was provided.

For the soil moisture studies six maize seeds were planted in 15-cm diameter pots and thinned to four plants after emergence. The treatments were replicated four times with pots arranged in a randomised block design on a glasshouse bench. For the first week after planting soil moisture was maintained close to field capacity and after that pots were allowed to dry out. Two days before treatment the soil moisture of the pots was adjusted to either 100, 70 or 55% of field capacity (FC). These levels were maintained for 14 days after treatment by weighing and surface watering each day. Treatments (Table 1) were applied 14 to 16 days after planting, when the maize was 150 to 200 mm tall. Applications were made with a single nozzle glasshouse sprayer applying 300 litres/ha at 210 kPa. A white emulsifiable crop oil (BP Crop oil) was added to all herbicides at the rate of 2 litres/ha.

The soil mobility experiments were carried out in 30-cm columns (10 cm diameter) as described by Rahman and James (1989a). The soil in a field moist condition was screened through a 5-mm sieve and then packed into a column to a height of 24 cm. A 5-cm layer of soil treated with the required concentration of herbicide was placed on top of the column. Each herbicide was used at a concentration which was equivalent to two to four times its field use rate (Table 2). Treatments were replicated four times. A nylon string marker was placed between the treated layer and the untreated soil in the column to act as a reference point for measuring movement. Water was added to each column in 20 ml aliquots over a 48-hour period until the water had reached the bottom of each column. After standing for a further 12 hours to reach equilibrium, the columns were laid on their sides and opened longitudinally. Two or three seeds of either maize or annual ryegrass were planted in each 2-cm increment and later thinned to one or two seedlings respectively after emergence.

Herbicide response was evaluated by regular visual assessments and harvesting top growth for dry matter determinations about 4 weeks after planting.

RESULTS AND DISCUSSION

Soil moisture

All three experiments on effect of soil moisture gave similar results which were therefore averaged and are presented in Table 1. At the lowest rate the herbicides had very little activity and there were no differences that could be attributed to the effect of soil moisture levels. For sethoxydim at the two higher rates there was a significant

TABLE 1: Effect of different soil moisture levels on the phytotoxicity of some grass herbicides to maize. (Average of three experiments).

		Dry shoot weight of maize*		
		Soil moisture (% field capacity)		
Herbicide	Rate (g ai/ha)	100	70	55
sethoxydim	22	98	87	96
	45	71	75	89
	60	45	52	81
quizalofop	4	94	100	97
	6	65	70	91
	10	13	38	71
clethodim	4	104	93	97
	6	82	84	86
	10	65	78	84

LSD between columns (differences due to soil moisture) is 7.5 ($P<0.05$).
LSD between rows (differences due to herbicide) is 13.7 ($P<0.05$).

*Dry shoot weight as % of untreated plants grown under the same soil moisture regimes.

increase in phytotoxicity at 100% and 70% FC but not at 55% FC. Quizalofop and clethodim are much more active than sethoxydim so were tested at lower rates of application. At the highest rate of 10 g/ha quizalofop showed greater activity than clethodim but the phytotoxicity of both declined as the soil moisture was reduced from 100% FC to 70% FC to 55% FC.

These results show that the performance of these post-emergence herbicides is affected by moderate and severe soil moisture deficits. Rahman (1985) reported similar results with several post-emergence herbicides including sethoxydim. Reynolds *et al* (1988) in ^{14}C studies with sethoxydim and quizalofop found that absorption of the herbicide increased under conditions of increased drought stress but that basipetal translocation decreased. It is therefore reasonable to conclude that it is reduced translocation of the herbicide to the site of activity that results in loss of phytotoxicity rather than reduced absorption.

Soil mobility

In this method for determining soil mobility of herbicides phytotoxic symptoms (e.g. stunting or chlorosis) are produced in plants that are grown in soil containing sufficient herbicide to be biologically active. Typically, plants that are grown in the treated soil, and for some distance below in the column, are stunted. This effect diminishes and eventually disappears at some distance down the column. It is this distance that is taken to be the measure of mobility of the herbicide and is affected by several factors, such as; the rate of herbicide, amount of water added, the soil activity of the herbicide and sensitivity of the bioassay species.

The mean distance which each herbicide moved within the soil column is given in Table 2. There were some variations between the three experiments, but the relative mobility of each herbicide was fairly consistent throughout the series. Their ranking was quizalofop = < haloxyfop < fluazifop-butyl < sethoxydim < clethodim. The detection of mobility would be influenced greatly by the level of soil activity of these herbicides, although this has previously been reported to be low (James *et al* 1988; Rahman *et al* 1988).

In these experiments the herbicide rates used were two to four times the normal field use rate to overcome their low soil activity. The bioassay species used (Table 2) are known to be highly sensitive to the particular herbicides (Rahman 1985; James *et al* 1988; Rahman *et al* 1988). The amount of water added in each experiment was equal to 105-115 mm of rain over a 48 hour period which is equivalent to moderately heavy rainfall. Very little has been published on the comparative leaching of the herbicides tested here, so it is difficult to compare with other research. However, considering the high rate of herbicide used and the quantity of water added, the amount of movement recorded here demonstrates that these five herbicides are only slightly to moderately mobile in the soil. It would appear that they are unlikely to move laterally off site or vertically much deeper than the root zone when used at recommended rates.

TABLE 2: Comparative mobility of biologically active residues of five grass herbicides in 30-cm columns filled with a sandy loam soil.

Herbicide	Rate (kg ai/ha)	Distance leached (cm)			
		Expt 1	Expt 2	Expt 3	Av.
quizalofop	0.2	2.5	2.5	3.0	2.7
	0.4	6.0	3.0	5.0	4.7
clethodim	0.96	11.0	13.0	12.0	12.0
	1.92	12.0	14.0	18.0	14.7
fluazifop-butyl	3.0	8.5	7.5	7.0	7.7
sethoxydim	3.2	14.5	11.0	7.5	11.0
haloxyfop	1.2	5.5	6.0	7.5	6.4
LSD ($P<0.05$)		3.3	2.0	2.6	
CV %		18	12	14	
Soil moisture %		30	24	33	
Water added (ml)		860	920	820	

In spring and early summer, when these herbicides are most likely to be used, rainfall is often frequent, unpredictable and sometimes very heavy. The results presented here show that adequate moisture is necessary for optimal activity of the herbicide and that because of their low mobility they are unlikely to leach away from the root zone. Provided that there is a minimum of 2 hours for the herbicide to dry on the foliage (Rahman and James 1989b), rainfall should not reduce the effectiveness of these herbicides.

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