LEACHING AND MOVEMENT OF IMAZAPYR IN DIFFERENT SOIL TYPES

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SUMMARY

Field and glasshouse experiments were conducted over a 2-year period to investigate the mobility of the herbicide imazapyr, using bioassay techniques with radish (*Raphanus sativus*) and oats (*Avena sativa*) as test species. Depth of leaching in the field was proportional to the rate of application, with phytotoxic residues from 0.25 kg/ha moving down to 150 mm, while at higher rates (1.0 and 2.0 kg/ha) significant residues were detected down to 300 mm. Mobility studies in PVC columns in the glasshouse showed the following order of movement in the six soil types used: sand > sandy loam > silt loam > clay loam. Moderate rates of water (14-28 mm rain equivalent) moved imazapyr 40-180 mm down the column while high water rates (≈200 mm rain equivalent) leached it through the entire length of the column, demonstrating its high mobility in the soil.
Keywords: imazapyr, mobility, leaching, bioassay.

INTRODUCTION

Imazapyr, a broad-spectrum herbicide, has shown excellent activity against annual and perennial grass and broadleaf weeds, vines and deciduous trees (Winfield and De Ath 1985). It has demonstrated good potential for pine (*Pinus* spp.) release and has provided good control of many woody brush and herbaceous weeds including *Cortaderia* spp., a problem weed in New Zealand forestry (Aschbacher *et al.* 1990; Davenhill 1988). Currently imazapyr is registered in New Zealand for industrial weed control at rates between 1.0 and 1.5 kg/ha, although field trials suggest that good long term control of difficult weeds such as Californian thistle (*Cirsium arvense*) and field bindweed (*Convolvulus arvensis*) is possible at much lower rates (Heering and Peeper 1991; Rahman and Sanders 1992).

Under field conditions the activity of imazapyr has persisted in the soil from 3 months to 2 years. For example, its residues reduced grain yield of wheat (*Triticum aestivum*) seeded 15 months after treatment and the suggested minimum waiting period between spraying and planting of containerised pine was from 3 months to over 12 months (Ciarlante *et al.* 1983). The water solubility of imazapyr is approximately 10 g/litre at pH 7, which suggests a potential for leaching through the soil profile. The adsorption and movement in the soil are influenced by soil pH, texture, moisture and other environmental variables (Peoples 1984; Wehtje *et al.* 1987). There are few published data concerning the behaviour of imazapyr in soils and none pertaining to New Zealand conditions. The objective of these glasshouse and field studies was to evaluate the leaching and movement of imazapyr in a number of different soils.

MATERIALS AND METHODS

Bioassay standards

Initial glasshouse experiments were conducted in two soils viz: Horotiu sandy loam and Hamilton clay loam (Table 1) during 1990, to select the most suitable bioassay species and to establish 'standards' for the activity of imazapyr (Arsenal). A range of concentrations (between 0.001 and 0.5 mg/kg soil) was used for these experiments. The required amount of herbicide was added in 100 ml of water to sufficient soil for eight pots. The soil was thoroughly mixed in a polythene bag and stored overnight to equilibrate. Seven bioassay species (listed in Results) were seeded at 10 mm depth in 120 mm diameter pots and thinned to eight plants after emergence. All pots were sub-irrigated to maintain the soil between 80% and 100% field capacity. Biological activity of imazapyr was assessed visually and by determining dry matter weight of shoots after 4 weeks.

Field study

Two field trials were conducted on a cultivated soil on the outskirts of Hamilton. The soil was a Horotiu sandy loam (Table 1) which is derived from volcanic ash and has 100% allophane as its clay fraction. Four rates of imazapyr, viz. 0.25, 0.50, 1.0 and 2.0 kg/ha were applied to the bare soil on 7.12.90 (Trial 1) and 9.9.91 (Trial 2) with a precision plot sprayer in 300 litres/ha water at a pressure of 200 kPa. Individual plots were 2 m x 8 m and treatments were arranged in a randomised block design with six replications. Soil samples for bioassay of residues were collected at 3 monthly intervals from 0-75, 75-150, 150-225 and 225-300 mm depths to determine the movement of imazapyr down the soil profile. The soil samples were mixed thoroughly and then used to plant out one pot each of radish and oats in the glasshouse. Plants were grown for 4 weeks before harvesting for dry matter determinations as described above.

Glasshouse experiments

These experiments were performed in 300 mm long PVC columns of 100 mm inside diameter (Rahman and James 1991). The soils (Table 1), in a field moist condition (20-25% water content), were screened through a 4 mm sieve and then gently packed into the columns to a height of 260 mm. Two string markers were placed on top of the soil followed by a further 20 mm of soil into which the required amount of imazapyr (equivalent to 1 kg/ha) had been mixed. The soil was topped with a sheet of filter paper and 10 mm of washed sand to give an evenly distributed water load to the top of the treated soil. Water was added to each tube in 20 ml aliquots over a 2-3 day period. Each soil column received a different amount of water from 100-3200 ml (Table 3). On completion of the watering regime, the columns were left to drain and equilibrate for 16 hours. The columns were then topped up with untreated soil, capped, laid on their side and opened longitudinally. Three radish or three oat seeds were planted at 20 mm intervals along the length of the column. There were three replicates of each bioassay species per watering regime. On emergence the seedlings were thinned to two plants and grown for another 2-3 weeks in the glasshouse without further watering and then harvested and dried. The distance leached was determined as the distance from the string markers to the first plants that had a dry weight of at least 85% of equivalent plants in the untreated columns. The experiment was conducted at least twice on each soil type.

TABLE 1: Some characteristics of the soils used in the mobility studies.

Soil type	Sand (%)	Silt (%)	Clay (%)	Organic C (%)	pH	Field capacity (%)
1 Mangateretere silt loam	17	49	32	2.9	6.1	33.7
2 Te Kauwhata clay loam	34	23	43	2.4	7.3	33.1
3 Hamilton clay loam	55	18	27	3.1	5.2	36.1
4 Horotiu sandy loam	58	27	15	6.2	5.8	45.1
5 Waikato sand	87	12	2	4.5	5.6	48.6
6 Te Teko sandy loam	89	10	2	5.7	5.4	35.2

RESULTS AND DISCUSSION

Bioassay standards

The effects of known concentrations of imazapyr on four bioassay species in the Horotiu sandy loam soil are presented in Fig. 1. These data, which are the average of several series of 'standards', show that white mustard (*Sinapis alba*) was most susceptible to imazapyr followed closely by radish. The susceptibility of annual ryegrass (*Lolium multiflorum*) was between radish and oats while that of sorghum (*Sorghum bicolor*) and subterranean clover (*Trifolium subterraneum*) lay between oats and maize (*Zea mays*). From these, radish and oats were chosen for bioassays because of their range of sensitivity and ease of growing in the glasshouse throughout the year. In general, the level of biological activity was slightly higher in the Hamilton clay loam soil (data not presented) than in the Horotiu sandy loam soil for all test species. Data on visual damage to bioassay species supported the dry matter yields from various treatments. The most common visual effect of imazapyr was stunting, followed by chlorosis and then necrosis of the growing point and young leaves.

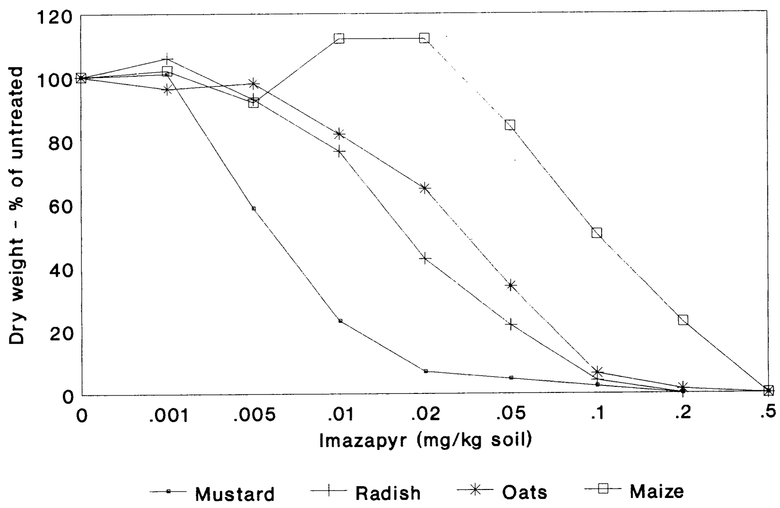

Figure 1: Effect of known concentrations of imazapyr on shoot dry weight of four bioassay species in the Horotiu sandy loam soil (standards). Average standard error of difference (SED) for data in the range of 20% to 80% is 4.7.

Field trials

Bioassays of the soil samples collected from different depths showed that phytotoxic amounts of imazapyr eventually moved down to lower depths at each rate tested, although most of the herbicidal activity remained in the top 75 mm of the soil (Table 2). In plots treated with 0.25 kg/ha, phytotoxic residues were detected at 75-150 mm depth in samples collected 1 and 2 months after application in the radish bioassay (data not presented). At the higher rates, imazapyr moved down to the lowest depth tested (225-300 mm) in significant quantities. Although the length of persistence was slightly shorter, similar trends for movement of imazapyr through the soil profile were apparent with the oat bioassays.

Results of Trial 2 were similar to those in Trial 1, except for a higher residual activity in the lower soil depths (i.e. slightly greater mobility) during the first 3-4 months. This may have been caused by a high rainfall of 147 mm during the first month after application in Trial 2, compared to 20 mm in Trial 1.

Glasshouse experiments

The average distance that imazapyr moved within the soil columns, as determined by the radish bioassay, is given in Table 3. Results from the oat bioassay were similar. It was found that it required between 400 and 500 ml of water to fully wet the soil columns filled with either of the sandy soils (Soils 5 & 6 Table 3) while it required 800

TABLE 2: Dry shoot weight of radish as percentage of untreated control after growing in soil sampled at four depths from a field treated with imazapyr.

Imazapyr (kg/ha)	Sampling depth (mm)	Months after application 3	6	9
0.50	0 - 75	7[1]	80	*102*
	75 - 150	22	*99*	*110*
	150 - 225	49	*111*	*106*
	225 - 300	*107*	*113*	*99*
1.00	0 - 75	0	21	71
	75 - 150	0	38	80
	150 - 225	6	72	*122*
	225 - 300	41	81	*104*
2.00	0 - 75	0	11	58
	75 - 150	0	24	46
	150 - 225	0	28	67
	225 - 300	0	40	80

[1] Figures in this table, except those in italics, are all significantly lower than untreated controls (=100), P<0.05, pooled SED 5.9.

to 900 ml to wet the other soils. For the smaller amounts of water added the soil was only wet part way down the column and this distance was often as far as the imazapyr was leached. In these columns, the presence of the herbicide in the soil was very obvious as the bioassay plants went from practically no growth to unaffected growth in a distance of 40 mm.

Imazapyr was most mobile in the very sandy soils (Soils 5 & 6) where 400 ml of water leached the herbicide nearly to the bottom of the column (Table 3) and least mobile in the heavy clay soils (Soils 1 & 2) where 1600 ml of water was required to leach the herbicide to the bottom of the column. In the Hamilton and Horotiu soils (Soils 3 & 4), with a 55 and 58% sand content, the extent of movement of imazapyr was intermediate. Of the soil properties given in Table 1, the sand content had the most impact on the mobility of imazapyr with a simple regression between distance leached and sand content accounting for at least 94% of the variation in the 200 and 400 ml water regimes. The organic C content, pH and field capacity of the soil appeared to have only minor effects on the mobility of this herbicide.

TABLE 3: Mobility of 1.0 kg/ha imazapyr as determined by radish bioassay in six soils after addition of different amounts of water.

Water added (ml/column)	Distance leached (mm) Soil 1[1]	Soil 2	Soil 3	Soil 4	Soil 5	Soil 6	LSD (P<0.05)
100	40	40	60	80	80	120	13
200	70	80	100	120	160	180	20
400	110	130	160	170	220	240	30
800	180	190	240	240	>260	>260	-
1600	>260	>260	>260	>260	>260	>260	-
LSD (P<0.05)	18	15	17	19	30	24	

[1] For details of soil types see Table 1.

The distance that a set amount of water will penetrate the soil depends on the current moisture status and the water holding capacity of the soil. The soils used in these experiments are typical of the cropping soils of the North Island and the smaller amounts of water added were not excessive (100 ml per column equals 14 mm of rain). With a water solubility of approximately 10 g/litre, imazapyr is among the most soluble herbicides and this is clearly demonstrated by its mobility within the soil in these experiments. Also imazapyr was not strongly adsorbed to the soils, even those with a high organic carbon and/or clay content, as after the high water regime of 3200 ml the bioassay plants were able to grow in many of the columns indicating that most of the herbicide had leached completely from them.

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