

A SIMPLE TECHNIQUE FOR DETERMINING HERBICIDE MOBILITY IN SOILS

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SUMMARY

A simple, inexpensive and effective technique is described for investigating the mobility of herbicides in soil and for evaluating the effects of factors such as soil type and rainfall. Results on the mobility of hexazinone using this technique are presented. The herbicide treated soil was placed on top of PVC columns filled with soil and different quantities of water were applied in small aliquots. Mobility of hexazinone was determined by measuring its biological activity along the length of soil columns with white mustard (*Sinapis alba*). Results show the high mobility of this herbicide in soil and how its movement is affected by different amounts of water.

Keywords: hexazinone, mobility, leaching, bioassay

INTRODUCTION

The distance a herbicide moves vertically in the soil is important in determining its efficacy as well as its potential for crop damage and environmental pollution. Numerous laboratory and field studies have been conducted on movement of herbicides in soils and factors influencing them. However, many of the methods that have been used are slow, expensive or complicated.

Investigations on evaluating the mobility of herbicides in different soils have measured the movement of the test compound either through modified thin-layer chromatographic techniques (Gerber *et al* 1970; Helling and Turner 1968; Wu and Santelmann 1975) or through uniformly packed soil leaching columns (Weber and Peeper 1982; Weber and Whitacre 1982). The most satisfactory method is one which best approximates actual field conditions and is reproducible. Mobility of herbicides in soil columns has more closely approximated field conditions than most other methods (Weber and Whitacre 1982) and also allows variations in the amount and rate of water addition over different time periods. This is important because the amount of water entering the soil as a function of time is the most significant factor affecting water and chemical movement in soil (Stockinger *et al* 1965).

This paper describes a simple, inexpensive and efficient technique to evaluate the rate of movement of herbicides in different soils under various conditions of rainfall or irrigation. Data are presented from experiments on movement of hexazinone using this method.

MATERIALS AND METHODS

Column preparation

Thirty cm long columns were cut from polyvinyl chloride (PVC) pipe of 10 cm inside diameter. Each column was cut longitudinally to make a 4-cm wide gap down the side which was covered with clear acetate film. A perforated PVC cap was then attached to the bottom of the column before filling with soil (Fig. 1).

Soil preparation

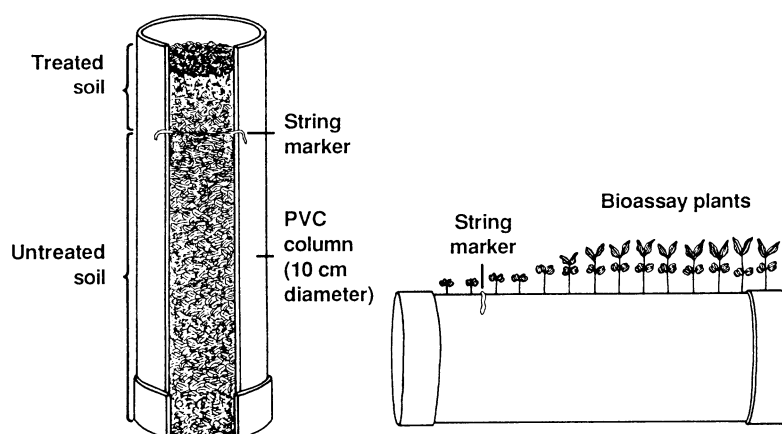
The soil, in a field-moist condition, was screened through a 5-mm sieve before adding to the column. Initial experiments with air-dry soil were unsatisfactory as it was difficult to wet and hindered the free flow of water causing irregular movement and unwanted channelling in the columns. The soil was gently packed into the column to the required height, leaving a space for the treated soil on top. After allowing the column to

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settle for 24 h, a 1 to 5-cm thick layer of soil containing the required rate of herbicide was placed on top of the column, leaving a gap of 1 cm for adding the water. 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 herbicide movement at the end of the experiment.

The soil used for these experiments was an Oruanui sand with a pH of 5.1 and contained 9.5% organic C, 8% clay and 67% sand. This soil is derived from volcanic ash and contains 100% allophane as its clay fraction.

Fig. 1: Diagrammatic representation of the PVC column filled with soil (left) and with bioassay plants growing (right).



Chemical preparation and application

The amount of herbicide applied was calculated from the soil surface area at the top of the column, the amount of treated soil to be added and the field use rate. The required amount of herbicide was applied in 100 ml water/kg of soil and was thoroughly mixed with the soil. A pre-determined amount of treated soil was then added to the top of the column forming a 1 to 5-cm thick layer. Each herbicide treatment was replicated four times.

For the present experiments the required concentration of the herbicide was mixed in 50 g soil, which formed a layer approximately 1 cm deep. The amount of hexazinone (Velpar L) applied to each column was 0.01 g or 0.05 g which is equivalent to 1/100th and 1/20th of the rate recommended for spot treatment of brush weeds in pastures, with a spot gun or an injector spear.

Leaching of herbicides

The columns were placed on a bench in the laboratory and water was added to the top of each soil column with a pipette in 20 or 40 ml aliquots over a 48-hour period until the required amount of water was added or until the water had uniformly reached the bottom of the column (Table 1). The columns were left to equilibrate for 24 h before each was filled with 1 cm of untreated soil at the top and capped. They were then laid on their sides and opened longitudinally by removing the clear acetate. The soil was scraped to level it with the side walls in preparation for bioassays in the glasshouse.

Glasshouse bioassays and assessments

The bioassay species to be used in the glasshouse would depend on the herbicide being investigated. White mustard was found the most suitable test species for measuring the biological activity of hexazinone in the soil. Three seeds of mustard were planted in each 2-cm soil increment and were thinned to two seedlings after emergence.

The columns were surface irrigated to maintain the soil between 80% and 90% field capacity. The plants were grown in a glasshouse with day temperatures of 22-26 °C and night temperatures down to 16 °C. No artificial light was provided. The experiment was repeated three times (Table 1).

After 2-3 weeks of growth in the glasshouse, plants were assessed for herbicide damage and then harvested for dry matter determinations. These DM data were used to assess the depth to which the chemical had moved in the soil within the column. A 2-cm soil increment was considered to be free of herbicide if the shoot dry weight was within 90% of that recorded in the untreated soil of the control columns. The distance from the string marker to the soil increment determined to be free of herbicide was then recorded and the data were analysed.

RESULTS AND DISCUSSION

Mustard was quite susceptible to hexazinone and the seedlings either died soon after emergence (at cotyledon stage) or continued to grow relatively unaffected, demonstrating the presence or absence of phytotoxic amounts of the herbicide. There was very little interface where plants were only partly affected. The distance measured in the present experiments was, therefore, often to the last dead plant in the soil column. With many herbicides, such as those belonging to the sulfonylurea group, the most common effect is stunting of plant growth (Rahman 1989) in which case plant height, vigour or visual damage symptoms could be important assessments. Assessments and measurements should be made as soon as there is sufficient shoot matter to be harvested for measuring dry matter, to avoid the roots of unaffected plants moving into treated soil and to restrict further movement of herbicide within the soil column due to regular watering. In the present experiments 7-10 days after emergence, or soon after plants in the contaminated soil had died, was found to be the most suitable time for measuring the movement.

The average distance which each rate of hexazinone moved within the soil column is given in Table 1. There were only small variations between the three experiments in the distance leached and the relative mobility at each herbicide rate and water volume, demonstrating the good reproducibility of results with this technique. The distance which hexazinone moved increased with the amount of water added to the soil column. When sufficient water was added to wet the entire length of the soil column (800 ml in this case), hexazinone moved through the column length in phytotoxic amounts at both concentrations (Table 1).

A 100 ml addition of water to the soil column approximately equates to 14 mm of rainfall. The four water rates used in these experiments are thus equivalent to 14, 28, 56 and 112 mm rainfall. The average precipitation over the summer months in the Wairakei area, where the Oruanui soil was obtained, varies between 60 and 100 mm/month. Data presented in Table 1 therefore suggest that hexazinone could be characterised as a very mobile compound. Its high water solubility (33000 ppm at

TABLE 1: Mobility of hexazinone in a 30-cm column filled with a sandy soil at two concentrations (0.01 and 0.05 g ai/column) as affected by amount of applied water.

Water added (ml/column)	Distance leached (cm)					
	Exp. 1 (18.12.89)		Exp. 2 (11.1.90)		Exp. 3 (9.2.90)	
	0.01	0.05	0.01	0.05	0.01	0.05
0	3.5	6.5	4.0	5.5	5.0	7.0
100	9.5	11.5	10.0	14.5	11.5	16.5
200	14.0	16.0	15.0	15.5	16.0	18.0
400	19.5	19.5	22.5	23.5	20.0	22.5
800	26.0	29.0	≥30.0	≥30.0	27.0	≥30.0
LSD (5%)	2.2	1.8	4.7	4.3	2.0	3.3

25 °C), the long persistence in the soil (Gaskin and Zabkiewicz 1986; Rahman 1981), the extensive leaching behaviour reported by Harrington *et al* (1982), and the high mobility measured in these experiments suggest that hexazinone would move down soil profiles in phytotoxic amounts and pose groundwater contamination problems, especially in light sandy soils.

The distance which a particular herbicide moves within the soil depends on a number of factors including water solubility and other chemical properties of the herbicide, soil characteristics, and the amount and intensity of water added. Many investigations have shown that soil organic matter content is the major factor affecting herbicide movement because of its capacity to retain the herbicide in the surface zone (eg Weber and Whitacre 1982). Soil texture also has a major effect on herbicide mobility. Kohnke (1968) has shown that water conductivity is greatest in fine textured soils and least in coarse textured soils under unsaturated flow conditions. Interestingly the opposite occurs under saturated flow conditions and this phenomenon could account for many of the differences in results obtained with different experimental leaching techniques. For a method using bioassay procedures such as the one reported here it is essential that the test herbicide has a reasonable persistence and biological activity in soil.

The results presented here demonstrate a simple, effective and efficient technique for investigating the mobility of herbicides in soils. The technique is not quantitative, although estimates of herbicide concentrations could be made by comparing the reduction in growth of bioassay plants with standard response curves based on known concentrations of the herbicide. By using this relatively easy and practical method, the importance of soil type and rainfall on the mobility of a herbicide through the soil profile can be predicted. The technique could be especially useful for comparing the mobility of different herbicides and can be very accurate if the herbicides belong to a group with similar chemical or biological properties.

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