INTERACTION OF HEXAZINONE WITH TWO SOILS AND THREE FERTILISERS

J.A. ZABKIEWICZ and R.E. GASKIN

*New Zealand Forest Service
Forest Research Institute, Private Bag, Rotorua*

SUMMARY

Hexazinone was slurried with sandy-loam and clay-loam soils in the presence or absence of diammonium phosphate, triple superphosphate and ground phosphate rock. The first two fertilisers caused extensive degradation within 3 weeks. Compared with soil-only incubations the effect of the last fertiliser was negligible. Hexazinone was also degraded extensively in a water solution containing triple superphosphate. Microbial effects were of little consequence nor was there much soil-adsorption of hexazinone in any treatment combination.

INTRODUCTION

Radiata pine (*Pinus radiata*) crops planted on nutrient deficient sites require fertilising at establishment. The system developed in New Zealand forestry is to apply soluble fertiliser in a spade slit beside trees at planting (Hunter and Graham 1983).

It has been observed that herbicides applied to control gorse often seem to be ineffective around recently fertilised trees, even where good control may exist between trees. This prompted an investigation to establish if the phosphorus (P) fertilisers — diammonium phosphate, triple superphosphate and ground rock phosphate — were responsible for any chemical degradation of the soil-active herbicide hexazinone.

MATERIALS AND METHODS

The ground rock phosphate (GRP) used was a 1:1 mixture of Christmas Island and Nauru Island A grade rock (M.F. Skinner pers comm). GRP is considered 'unreactive'; averages 14% P concentration and is essentially insoluble in water. The triple superphosphate (TS) is a concentrated superphosphate containing approximately 21% P and having 90% water solubility. Diammonium phosphate (DAP) incorporates 20% P, and is totally water soluble.

Two soils were chosen from areas exhibiting 'failure' when herbicides were applied to control gorse regrowth after fertilisation. They were a moderately acidic, sandy-loam soil, very low in extractable P, from Motueka State Forest in Nelson and a clay-loam type of similar acidity and P level from Otangaroa State Forest, Northland. Both soils were sampled from 0-20 cm depths.

Soils were air-dried at ambient temperature, sieved, duplicate lots weighed out and steam sterilised before use.

Distilled water was used at all times. Samples of solution or slurry supernatant were taken at fixed intervals, filtered through a Minisart NP filter (0.45 μm) as appropriate and 20 μl duplicate aliquots placed in vials to be neutralised with sodium bicarbonate. Ten ml acetonitrile:water (40:60) was added and herbicide extracted into this phase. Herbicide analysis was done by HPLC (high performance liquid chromatography) on a C8 Reversed-Phase column coupled with a C18 guard column. Duplicate 20 μl samples were eluted with a 40:60 acetonitrile:water mobile phase at 1 ml/minute. Quantitation was by sample peak height over the concentration range 1-40 ppm.

(A) Fertiliser effect

Hexazinone (Velpar SP) was dissolved in water (4 mg/ml) alone and in combination with the three fertilisers (250 mg/ml), for a period of 30 days. The

Proc. 38th N.Z. Weed and Pest Control Conf.

solutions (40 ml) maintained at room temperature (18-20 °C) were stirred constantly for the first hour and then for 5 minutes before each sampling. Aliquots were taken throughout the first day and then at intervals over 1-30 days. The pH of each solution was measured at sampling.

(B) Fertiliser/soil effect

Hexazinone (2.5 mg/ml) was made up as described in (A). These solutions were slurried in the presence of the two soil types (20% wt/v; soil:fertiliser ratio 1:1) and the same conditions. They were sampled at intervals over 23 days.

(C) Soil binding effect

Hexazinone was combined as in (B) with water, fertilisers and sterile soils. After 3 days the solution was filtered off and the filter cakes washed with 2 x 40 ml water before extracting them twice with acetone (100 ml for 2 h with shaking). The acetone extracts were combined, duplicate aliquots (500 µl) removed, blown to dryness and made up in solvent for analysis. The aqueous filtrates were sampled and analysed for herbicide as before.

(D) Fertiliser dilution effect

Hexazinone was individually combined with the fertilisers DAP and TS at three different concentrations, in the presence of the clay loam soil. The fertiliser:herbicide:soil ratios were 100:1:100; 10:1:100; 1:1:100.

Solutions were stirred continuously for the first hour, the pH measured, then shaken vigorously for 1 min. every second day over a 14 day period.

(E) Non-sterile soil effect

Hexazinone was slurried with water and the three fertilisers, plus sterile and unsterile soils as in (B). The solutions were quantitatively sampled for herbicide after 3 days.

RESULTS AND DISCUSSION

(A) Hexazinone in combination with the two 'neutral' fertilisers, GRP and DAP, showed little decrease in concentration over 30 days. The DAP solution (pH 7.5) showed a decrease of approx. 10% in comparison to the control, and the GRP solution 20% (pH 6.5). The acidic TS solution (pH 2) showed 90% decrease in concentration of hexazinone after 30 days. In aqueous solution hexazinone is susceptible to rapid degradation under acidic conditions, though it is reported as stable at pH 5-9 at 20 °C (Worthing and Walker 1983). The effect of the fertilisers on the degradation of hexazinone was assumed to be directly related to herbicide solubility and solution pH. Hexazinone has a solubility of 33 mg/ml in water; hence, all was in solution at the rate (4 mg/ml) used in this experiment.

(B) The soils chosen (Table 1) were moderately acidic but had no obvious effect on the pH of the herbicide/fertiliser solutions. There was negligible loss of hexazinone in the control solution with each soil (Fig. 1) at 23 days, neither did the presence of GRP show an effect. DAP caused a 40% loss of hexazinone with the sandy and a 50% loss with the clay soils. In combination with the acidic TS detectable herbicide in both soil slurries dropped to 30% after 23 days.

TABLE 1: Soil properties*

	Mechanical analysis			Chemical analysis			
	Sand (%)	Silt (%)	Clay (%)	Bray P (ppm)	P retention (%)	Conductivity (mohm)	pH
Clay loam (Otangaroa S.F. Northland)	42.2	21.9	35.9	2.3	58.2	0.04	5.22
Sandy loam (Motueka S.F. Nelson)	70.7	19.5	9.8	2.1	50.6	0.04	5.34

*Analysed by standard FRI Method (Nicholson 1984).

Fig 1: Effect of phosphate fertilisers on hexazinone concentration in the presence of two soils.

(C) After 3 days, hexazinone in solution with GRP showed approx. 2% deactivation in both soils (Table 2) and most of this was analysed as bound, not degraded. The DAP and TS fertiliser treatments gave the expected greater deactivation of herbicide, but with a lesser proportion found bound to the soil. Chemical degradation was the main pathway in both these soil/fertiliser combinations.

TABLE 2: Hexazinone after 3 days in fertiliser/soil solution - soil binding vs. degradation.

	% of starting concentration							
	Clay loam				Sandy loam			
	DAP	TS	GRP	Control	DAP	TS	GRP	Control
"available"	81.0	69.1	98.5	90.7	76.0	63.4	97.8	94.8
"bound"	7.3	9.6	1.5	N/A	6.6	10.7	1.6	N/A
"degraded"	11.7	21.3	0	N/A	17.4	25.9	0.6	N/A
pH	7.5	2.0	6.5	6.0	7.5	2.0	6.5	6.0

"available" herbicide analysed in aqueous slurry

"bound" herbicide extracted in acetone washes

"degraded" herbicide unaccounted fraction

N/A Not analysed

(D) Ratios of fertiliser:herbicide:soil were selected (Table 3) to cover the concentrations anticipated in the field from either broadcast or slit application method.

After 14 days, more hexazinone was present in treatments with lower fertiliser concentrations. The amounts of TS and DAP fertilisers in the soil slurry with hexazinone have a considerable effect on the pH and chemical degradation of herbicide. In either case it may be presumed that the low and high pH conditions contributed to the hexazinone degradation.

TABLE 3: Effect of fertiliser concentration on hexazinone in clay loam slurry (at 14 days).

Herbicide	Fertiliser	Concentration (mg/ml)	% of starting concentration		pH
			in aqueous solution	unaccounted for	
Hexazinone (2.25 mg/ml)	DAP	250	49.2	50.8	8.0
		29	85.4	14.6	7.5
		2.6	86.0	14.0	5.2
	TS	250	42.8	57.2	2.5
		27	87.4	12.6	3.5
		3	91.4	8.6	4.0

(E) There appeared to be no consistent contribution from non-sterile soil to measured degradation of hexazinone with all fertilisers and both soil types (Table 4). Harris *et al* (1968) reported that with triazines microbial degradation occurs slowly. Microbial action is reported by Rhodes (1980) as having an effect on hexazinone in soil, but only after a lag period of approximately 20 days. The present results support the findings of Harris *et al*. All soils were sterilised before use in the preceding experiments to remove this variable microbial effect.

TABLE 4: Effect of sterile and non-sterile soils on hexazinone in solution with fertilisers (at 3 days).

Soil	% of starting concentration in solution							
	Clay loam				Sandy loam			
	Control	DAP	TS	GRP	Control	DAP	TS	GRP
Sterile	90.7	49.7	55.0	77.7	94.8	64.1	57.1	92.5
Non-sterile	94.5	51.6	50.8	85.7	87.1	59.8	55.4	87.7
Extra degradation in non-sterile	-3.8	-1.9	4.2	-8.0	7.7	4.3	1.7	4.8

CONCLUSION

In situations where fertilisation and weed control are essential, GPR fertiliser can be expected to have little effect on hexazinone, either by direct degradation or indirectly by soil-binding. TS and DAP in comparison, are liable to reduce considerably hexazinone effectiveness.

The reason for increased deactivation in soils containing TS could be attributed to high acidity, but the degradation also promoted by the DAP fertiliser-soil slurries points to other factors being involved. If pH is not the sole determining factor in herbicide degradation then a more complex chemical interaction is implicated.

It is concluded that fertiliser:herbicide interaction as demonstrated with hexazinone and TS or DAP may be a further obstacle to successful weed control. The use of rock phosphate would be a safe alternative.

ACKNOWLEDGEMENTS

Dr M. Skinner is thanked for advice and helpful comments in setting up the trial, and Mrs B. Kirk and H. Kroese for technical assistance. Soil analyses were made by Mrs G. Nicholson.

REFERENCES

- Harris, C.I., Kaufman, D.D., Sheets, T.J., Nash, R.G. and Kearney, P.C., 1968. Behaviour and fate of s-Triazines in soils. *Advanc. Pest. Cont. Res.* 8(1): 1-55.

- Hunter, I.R. and Graham, J.D., 1983. Three-year response of *Pinus radiata* to several types and rates of phosphorus fertiliser on soils of contrasting phosphorus retention. *N.Z. J. For. Sci.* 13(2): 229-38.
- Nicholson, G., 1984. Methods of soil, plant and water analysis. *N.Z. For. Serv., For. Res. Inst. Bull.* 70.
- Rhodes, R.C., 1980. Soil studies with ¹⁴C-labelled hexazinone. *J. Ag. Food Chem.* 28: 311-315.
- Worthing, C.R. and Walker, S.B., 1983. The Pesticide Manual, British Crop Protection Council, Lavenham Press, UK, 310.