EFFECT OF SOIL MOISTURE AND ORGANIC MATTER ON THE ACTIVITY OF ATRAZINE

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SUMMARY

The influence of soil moisture and organic matter (OM) levels on phytotoxicity of soil-applied atrazine was investigated using two Horotiu sandy loam soils with OM contents of 10.6% and 20.5% and three levels of soil moisture viz., 60%, 75% and 100% field capacity (FC). Atrazine was incorporated in the top 5 cm of soil in pots and oats (*Avena sativa*) were used as the test species. Activity of atrazine was considerably less in the high OM soil than in the low OM soil. As moisture in the soil decreased, particularly to levels which obviously stressed plants, atrazine became less toxic to oats.

INTRODUCTION

The concentration of a herbicide in soil solution is widely believed to be a critical parameter for effectiveness, regardless of the soil (Kratky and Warren 1973). However, a faster rate of herbicide uptake has been observed from nutrient solution than from a sandy loam soil which had the same concentration of herbicide in its soil solution (Geissbuhler *et al* 1963). This implies that the soil affects the toxicity of a herbicide.

Experiments with several soil applied herbicides, including atrazine, have shown that as soil moisture declined, a higher concentration of herbicide in the soil was required to produce the same plant response (Riley and Morrod 1976; Walker 1970). Studies have also shown that soil organic matter is the most important factor determining the biological activity of atrazine in soils (Grover *et al* 1983; Rahman and Matthews 1979).

Because of the possibility of competition between water and the herbicide solute for adsorption sites, this study was designed to investigate the water-soil relationship with the biological activity of atrazine applied to the soil.

MATERIALS AND METHODS

Bulk samples of Horotiu sandy loam soil were collected from the top 10 cm of two experimental sites, air dried and passed through a shredder. The two sites were selected to provide widely different organic matter levels. A representative sample from each site was taken for the determination of soil properties which are listed in Table 1.

TABLE 1: Chemical and physical properties of the soils used.

Site	Organic matter (%)	Organic matter (t/ha)	Clay (%)	Sand (%)	pH	CEC (meq/100 g)	Field capacity* (%)	Bulk density (g/cc)
1	10.6	76.3	14.5	61.7	5.8	28.4	39.8	0.72
2	20.5	137.4	15.1	57.2	6.0	34.2	41.1	0.67

* Water content by weight

Atrazine (Gesaprim WP) was added as an aqueous suspension in 50 ml of water/kg of soil to give the desired concentrations of parts per million by oven-dry weight (ppmw). Oats (*Avena sativa* cv. Mapua) were used to measure the phytotoxicity of the herbicide. All experiments were repeated five times at different times of the year between 1984 and 1985. In the first two, up to 15 concentrations of the herbicide were used in both soils to produce a complete response curve. The last three sets of experiments included only seven concentrations (Table 2).

TABLE 2: Effect of atrazine on dry weight of oats (expressed as % of untreated control) at different soil moisture and organic matter levels.

atrazine (ppmw)	Low organic matter			High organic matter		
	60% FC*	75% FC	100% FC	60% FC	75% FC	100% FC
0	100	100	100	100	100	100
0.2	104	89	85	101	106	97
0.3	84	61	54	107	94	83
0.4	55	32	21	88	79	68
0.5	34	9	0	81	66	57
0.6	21	0	0	72	54	44
0.7	8	0	0	61	34	26
0.8	1	0	0	45	18	6
SED	5.4	6.1	5.6	4.9	5.5	5.8

* Field capacity

Plastic pots 15 cm in diameter were filled with untreated soil to about 60% capacity and then weighed amounts of treated soil were added to each pot to provide a treated layer, 5 cm deep. Initial soil moisture levels were obtained by mixing the required amount of water separately to the treated and untreated components of the soil for uniform distribution of moisture within the pot.

Ten seeds of oats were planted at a depth of 2 cm and eight plants were established in each pot. The treatments were replicated four times and pots were arranged in a split-plot randomised block layout on glasshouse benches, with moisture levels as the main plot treatments. The glasshouse was maintained between 20 °C and 27 °C, with no artificial light.

Pots were weighed daily and water was added to the surface to bring each pot to its original weight. Throughout the experiment visual observations of plant growth and development of phytotoxic symptoms were recorded regularly. The final herbicide response was evaluated after 5 to 6 weeks by harvesting top growth and obtaining its dry weight.

RESULTS AND DISCUSSION

The effect of different concentrations of atrazine in the soil on the dry matter weight of oats is shown in Table 2. Top growth of plants progressively decreased with increasing concentrations, but the scale of reduction varied with the level of organic matter and the moisture content of the soil.

Initially oat seedlings appeared to grow normally at all concentrations without showing any injury symptoms. After 5-10 days when the seedlings were 7-10 cm high, chlorosis of leaves appeared at the higher concentrations (starting from the leaf tip), and soon after this symptom appeared at other concentrations of atrazine. At the highest rate, many or all plants were dead by the end of the experiment. These dead tissues were not harvested for dry matter determinations.

Toxicity of atrazine at each concentration was considerably higher in the low OM soil than in the high OM soil. This inverse relationship between phytotoxicity of atrazine and soil OM content has been shown previously (Grover *et al* 1983; Khan 1978). While most research workers have established such a correlation by addition of peat moss to low OM soils, this study confirms that a similar relationship exists with naturally occurring high levels of OM, without peat in the soil.

The relative effect of soil OM in reducing the phytotoxicity of atrazine was evident at all three levels of soil moisture. This shows the high potential adsorptive capacity of soil OM for atrazine as it was presumably able to remove the herbicide from the soil solution at all moisture levels, thereby reducing its efficacy. The immense importance of OM in adsorbing and modifying the behaviour of herbicides in the soil has been reviewed by several workers (e.g. Khan 1978).

Soil moisture also had a marked influence on the phytotoxicity of atrazine to oats (Table 2). As the soil moisture decreased, atrazine became less effective in reducing the

top growth of oats. This reduction in activity was greater when soil moisture was decreased from 75% FC to 60% FC than from 100% FC to 75% FC. At all atrazine concentrations growth of oat plants increased as the soil moisture was raised. Maximum growth of oats, without the herbicide, was obtained at the highest moisture level. Untreated plants growing at 75% FC did not show stress from lack of water. The 60% FC moisture level resulted in smaller height, narrower leaves and plants which clearly exhibited 'drought' symptoms. It appears, therefore, that the effect of soil moisture on activity of atrazine becomes much more pronounced when the moisture content drops to levels which have a marked effect on the growth of plants.

The availability of atrazine to plants is determined by the extent of its adsorption to both the hydrophobic adsorptive sites (i.e. the relative amount of soil OM) as well as the hydrophylic adsorptive sites (i.e. the relative amount of soil water). As the soil moisture decreases more atrazine is adsorbed on the now available hydrophylic surfaces, in addition to the amount adsorbed by the soil organic matter. This probably accounts for the steep reduction in the toxicity of atrazine between 75% and 60% FC.

The results presented here provide clear evidence that both soil OM and soil moisture levels significantly alter the phytotoxicity of atrazine applied to soil. The effectiveness of atrazine is markedly reduced at high OM levels and at soil moisture levels low enough to significantly stress plants. Within the range of soil moisture levels conducive to normal plant growth, variations in soil OM content are more likely to influence the effectiveness of atrazine than differences in the levels of soil moisture.

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