EFFECT OF PHOSPHORUS ON PHYTOTOXICITY AND RESIDUAL ACTIVITY OF ATRAZINE

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Summary

In the presence of relatively high, but non toxic, levels of phosphate in the soil the phytotoxicity of atrazine to turnips (*Brassica rapa*) was increased significantly. This effect was not observed at sub-lethal concentrations of atrazine nor at phosphate levels below 150 ppmw. Phosphorus concentration in plant tops increased with increments in the phosphorus levels of the soil but was unaffected by atrazine at low rates. At high concentrations of atrazine some significant increases in the phosphate levels of plant shoots were recorded, although such increases tended to vary directly with the size of the shoot. Bioassay data indicated that the persistence of atrazine was not affected by the addition of phosphorus to the soil.

INTRODUCTION

The amount of a herbicide adsorbed by the soil depends upon many factors including its rate of removal from solution by plant roots, type and concentration of other ions in the soil and constituency of the particles that comprise the soil system. Changing one or more of these factors influences the amount of chemical available to plants. Applications of large quantities of fertilisers or lime would, therefore, be expected to have some effect on the performance of soil applied herbicides under field conditions.

Additions of phosphorus to the soil have been reported to increase the toxicity of atrazine and simazine to soya beans (*Glycine max*) (Adams 1965; Stolp and Penner 1973). Atrazine phytotoxicity to maize (*Zea mays*) was also greater at high levels of phosphorus than at low levels (Doll *et al* 1970). This was attributed to phosphate effect on herbicide activity rather than to increased herbicide uptake. Atrazine has been shown to increase phosphate uptake by soya bean plants (Adams and Espinoza 1969), whereas in barley (*Hordeum vulgare*) and maize it had no significant effect on the phosphorus content of plant shoots (Doll *et al* 1970; Stolp and Penner 1973). Added nutrient materials have also been reported to increase degradation of atrazine in the soil but had no effect on the decomposition of linuron (Hance 1973).

The widespread use of fertilisers, especially superphosphate, on New Zealand soils may influence the activity of soil applied herbicides. This study was conducted to determine the effect of different soil phosphorus levels on the phytotoxicity and residual activity of atrazine and to find out if atrazine had any effect on phosphorus uptake by plants.

MATERIALS AND METHODS

This study consisted of six glasshouse experiments conducted between 1973 and 1975. Turnip (*Brassica rapa* cv 'Green Globe'), a species susceptible to atrazine, was used to measure the herbicide phytotoxicity. The soil was a Horotiu sandy loam of pH 5.5 and contained 14.8% organic matter, 53% sand, 25% silt, 16% clay, and a very low amount of

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available phosphorus. Treatments were arranged in a four replicate split-plot randomised block design with the phosphorus levels occupying the main plots and atrazine concentrations the sub-plots. Plastic pots, 15 cm in diameter, were used for all experiments.

Phosphorus was added in the form of calcium mono phosphate and mixed thoroughly with the soil one or two days before sowing. Other macronutrients and micronutrients were also added at concentrations estimated to produce optimum growth. Phosphorus levels used in these experiments varied between 50 and 1000 parts per million by weight of oven-dry soil (ppmw) and the rates of atrazine (in the top soil) were 0.15, 0.20, and 0.25 ppmw. The herbicide concentrations were selected so that the middle rate was close to the GR_{50} value — the rate which would result in a 50% reduction in the shoot growth as compared to the untreated control. Atrazine was mixed only with a portion of the soil which provided a top layer in each pot to a depth of 5 cm in which seeds were placed at 2 cm depth. At the start of each experiment the soil was brought to field capacity and watered thereafter between 75 and 100% field capacity. After emergence the seedlings were thinned to eight plants per pot. The plants were harvested after a growth period of 6 weeks and the dry matter weights of the shoot material were determined.

At the conclusion of each experiment the pots were allowed to dry for 2 days and then the upper 2 cm of soil was removed. The pots were reseeded with turnips, the soil was replaced and the process repeated to find out the residual activity of atrazine.

Phosphorus determinations in the plant tops were made by the Ruakura Plant Analysis Laboratory. The shoot material was wet digested and analysed colorimetrically by a vanadomolybdate method.

RESULTS AND DISCUSSION

The initial phosphorus level of the soil used in these experiments was so low that the smallest phosphorus addition produced a significant growth response (Fig. 1), with further marked increases in the dry weight of turnips from each increment up to about 400 ppmw. As larger amounts of phosphorus were added little or no additional growth response was obtained. The phosphorus content of plant tops on a percentage basis was found to vary directly with the phosphorus applied to the soil, although at higher rates the increases were fairly small. Atrazine had no significant effect on the growth of turnips at the lowest rate, while the highest concentration decreased the yield by 76% when compared to the untreated control (Fig. 2). Thus a wide range of measurable responses was induced by both phosphorus and atrazine rates used in this study to evaluate their effects alone and in combination.

The turnip shoot weights produced at various phosphorus levels in the presence of different rates of atrazine are shown in Fig. 2. When used below phytotoxic levels (0.15 ppmw), activity of atrazine was not affected by the addition of phosphorus. Similarly phosphorus levels of up to 100 ppmw did not significantly alter the phytotoxicity of atrazine at higher concentrations. But distinct interactions between phosphorus and atrazine were observed when both were added at high rates, as phosphorus levels over 100 ppmw significantly increased the phytotoxicity of atrazine at both 0.20 and 0.25 ppmw rates. This increase in atrazine's activity appeared to reach a maximum at about 200 ppmw of phosphorus and no significant differences occurred with further increments in the phosphorus level.

Phosphorus concentration in shoots from various phosphorus treatments were not influenced significantly by the lowest concentration of atrazine when compared with the no herbicide treatment. But some significant increases in the phosphorus level of shoots were recorded at the

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two high concentrations of the herbicide (Fig. 3). These variations, however, may be accounted for almost exclusively by relating the chemical composition to the size of the plant. The smaller the plant, the higher the concentration of phosphorus in the shoot. Thus atrazine does not seem to have any direct influence on the phosphorus concentration of plant shoots when turnips are grown in soils varying widely in their phosphorus content. This trend conforms with the previously reported observation of Upchurch *et al* (1963) for a number of soil applied herbicides. From experiments employing low rates of phosphorus, Meyer *et al* (1973) and Stolp and Penner (1973) concluded that atrazine did not markedly affect the uptake of phosphorus by plants.

Fig.1

Effect of different levels of phosphorous on the dry weight and phosphorous concentration of turnip shoots in the absence of atrazine

Fig.2

Influence of phosphorous and atrazine on the shoot dry weight of turnips

The bioassay data for residues of atrazine at the termination of experiments indicated that only the highest rate contained sufficient activity to cause significant reductions in the growth of turnips. The degree of persistence was not affected to any significant extent by the additions of phosphorus. These results do not agree with the findings of Hance (1973) who reported that addition of nutrient materials increased the degradation of atrazine. However, the materials used in his study included farm yard manure, straw or inorganic salts containing a number of elements and it could have been some other element (e.g. C or N) or their combinations which enhanced the degradation. Furthermore, Hance found no effect of nutrients on the degradation of linuron, and Rahman *et al* (1975) found no relationship between soil phosphorus levels and the persistence of trifluralin.

The results reported here on phosphorus-atrazine interactions are in agreement with the earlier findings of Adams and Espinoza (1969) and Stolp and Penner (1973), although the soil used in our experiments had a markedly higher organic matter content and thus a greater adsorptive capacity. Doll *et al* (1970) found a similar relationship using culture solutions with species both resistant and susceptible to atrazine. From a practical point of view data from this study suggest that the light to moderate rates of phosphorus application, which are commonly used in the cropping and pasture situations in New Zealand, should have no marked effect on the phytotoxicity of atrazine. However, at high rates of application a significant positive relationship could be expected between the phosphorus levels and the activity of this herbicide.

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- Figure 1: Effect of different levels of phosphorus on the dry weight and phosphorus concentration of turnip shoots in the absence of atrazine.
- Figure 2: Influence of phosphorus and atrazine on the shoot dry weight of turnips.
- Figure 3: Influence of phosphorus and atrazine on the phosphorus concentration in turnip shoots.