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STIMULATING SOIL MICROORGANISMS TO DECOMPOSE PYRIDINE HERBICIDE RESIDUES

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INTRODUCTION

Picloram, or Tordon, and Daxtron are two persistent herbicides that are lethal to many plants at a concentration of 0.1 p.p.m. but are non-toxic to many soil bacteria, actinomycetes, and fungi, even at concentrations up to 100 p.p.m. Yet in most soils, their decomposition is extremely slow, and months or years may pass before it is safe to sow new crops.

REVIEW OF THE LITERATURE

Meikle, Williams, and Redemann (1966) found that 4% of picloram, labelled with 14_C in the carboxyl position, was decarboxylated by plant roots and rhizosphere microorganisms in 15 days at 25-28°C. Redemann *et al.* (1968) using 0.9 p.p.m. of picloram, totally labelled with ^{14}C, in pots of wheat, detected traces of radioactive oxalic acid, 4-amino-3,5-dicholoro-6-hydroxy-picolinic acid, and 4-amino-2,3,5-trichloropyridine after 98 days. Rieck (1969) added organisms to glucose media containing 0.1 p.p.m. of picloram (carboxyl-^{14}C labelled) and found that *Rhodotorula glutinis* decomposed 24%, *Trichoderma* spp. 11% and *Aspergillus tamarii* 6% in 30 days.

RESULTS

Varying the moisture content, pH, temperature, or levels of organic substrates in soils had little effect on microbial degradation of picloram or Daxtron, but sterilization stopped decomposition. Numerous microorganisms isolated as pure cultures from soils enriched with picloram failed to decompose it after months. Soils enriched with thirty other pyridines, varying in phytotoxicity, degraded these compounds to different degrees, and in some cases pure cultures were isolated which also decomposed them. Fully substituted pyridines were much more recalcitrant and phytotoxic than partially substituted ones in the order 5 substituents >4 >3 >2 >1. Removal of one or two substituents from picloram or Daxtron and replacement by hydrogen gave molecules more than a hundred times less phytotoxic than the parent molecules, and some were more easily decomposed. Substituents close to the nitrogen of the pyridine ring had greater effects than those remote. Chlorine atoms conferred greater persistence and phytotoxicity in many pyridines than substituents such as amino, carboxyl, hydroxyl, or methyl groups. Two chlorine atoms usually produced greater effects than one. Two carboxyl groups, however, were no different from one, since the pyridine acids were usually easily decomposed and non-toxic to plants. In hydroxy-pyridines, two hydroxyl groups conferred greater persistence than one, but hardly changed phytotoxicity, which was low.

CONCLUSIONS

Considering how slowly picloram and Daxtron are degraded by microorganisms it is doubtful whether they could serve as useful sources of energy. Even a good source of energy, such as glucose, if added to soil in the same molar concentration as picloram, i.e. a few molecules sorbed per soil particle in a clay loam, would increase the generation time of bacteria from half an hour to 4½ days. Certain less substituted pyridines were good sources of energy and of nitrogen, and indiced the synthesis of adaptive enzymes in bacteria. By mixing inducer pyridines with recalcitrant pyridines it is hoped that soil microorganisms will multiply which will cometabolize herbicide residues. The problem of persistent residues might then be solved by spraying with mixtures containing herbicide, an inducer energy substrate, and a suitable microorganism or microorganisms to promote quicker decomposition.