

Herbicides and Collembola in Cotton-Growing Soils

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University of Sydney, NSW 2006

Introduction

Residues of agricultural chemicals in soil and run-off water are a major cause for concern in cotton production. Microorganisms are known to be important in residue degradation but the role of soil fauna in this process has received much less attention. In some cotton-growing soils the Collembolan, *Proisotoma minuta*, is a predominant species and may contribute to residue reduction. The effect of herbicides used in cotton-producing areas on *P. minuta* is being examined to determine whether residues are likely to be metabolised by the insect.

Methods

Using methods developed to study the effect of insecticides on *P. minuta* batches of about 14 insects cultured in the laboratory were placed on the surface of 2ml of sea salt solutions containing herbicides in sealed-lid glass vials. After 7 days, mortality was determined and the data were analysed using a probit program to determine LD₅₀ values.

Results

Nine herbicides which are or have been used in cotton production were used in this experiment. The LD₅₀ values of the herbicides for *P. minuta* are shown in the Table below.

Herbicide	LD ₅₀ (± range)	LD ₅₀ herbicide LD ₅₀ α-endosulfan	Lipophilicity of herbicide (K _{ow}) ¹
Simazine ²	>1000ppm	>100000	logP = 2.1
Diuron	710.9ppm (292.8-1726)	71090	logP = 2.85
Fluometuron	205ppm (167.2-251.2)	20500	logP = 2.38
Atrazine ²	33.4ppm (26.7-41.7)	3340	logP = 2.5
Paraquat	23.1ppm (16.2-33.0)	2310	N/A
Prometryn	13.0ppm (10.6-16.0)	1300	logP = 3.1
Metolachlor	12.4ppm (9.7-15.8)	1240	logP = 2.9
Pendimethalin	10.4ppm (7.4-14.6)	1040	logP = 5.18
Trifluralin	3.5ppm (2.7-4.5)	350	logP = 4.83

1. Reference: The pesticide manual (11th edition) by British Crop Protection Council, 1997.

2. Atrazine and simazine are not now used in cotton production, but they are used in other agricultural systems and residues remain in the soil in many areas.

Herbicides are much less toxic to *P. minuta* than endosulfan. Toxicity may be related to the lipophilicity of the herbicide which may affect the penetration of the chemical through the exoskeleton. Further study will be necessary to determine whether the herbicides are metabolised by the *P. minuta*.

This work is supported by the CRCSCP

The results in Table 1 show that the herbicides are much less toxic than any of the endosulfan insecticides. The difference in toxicity of herbicides to Collembola may be related to the lipophilicity of the herbicide. Lipophilic compounds may penetrate the exoskeleton of an insect more easily than hydrophilic compounds. In these assays of a limited group of herbicides the more lipophilic herbicides were more toxic to Collembola, but further study will be needed to find out whether there is a relationship between toxicity to Collembola and lipophilicity of the herbicide.

The results determined so far suggest that herbicide residues in soil are unlikely to be toxic to *P. minuta*. The herbicides examined are certainly much less toxic than endosulfan. The possible metabolism of the herbicides by *P. minuta* has not yet been determined.

Residues of agricultural chemicals in soil and run-off water are a major cause for concern in cotton production. The role of microorganisms in the degradation of such residues in cultivated areas has been studied intensively but the role of soil fauna in this process has received much less attention.

It has been shown that in some cotton-growing soils the Collembolan, *Proisotoma minuta*, is a predominant species. Samples of *P. minuta* from cotton-growing soils at Moree have been cultured in the laboratory and methods developed for obtaining sufficient quantities of the insects to enable toxicity studies using insecticides and herbicides to be carried out. It is possible that species such as *P. minuta* may contribute to residue reduction in cotton soils by metabolism of toxic compounds to less harmful materials.

AIMS:

The aims of this project as stated in the initial project application are:

- ① To make a preliminary assessment of the effect of herbicides used, and likely to be used, in cotton production on the Collembolan, *P. minuta* which is a predominant species of soil fauna in some cotton-growing soils.
- ② To determine whether herbicides used, and likely to be used, in cotton production are metabolised by *P. minuta*.

Research Plan

Year 1 Herbicides will be examined for their toxicity to *P. minuta* using the methods developed for studies on endosulfan toxicology. The effect of the herbicides will be determined by placing batches of the insects cultured in the laboratory onto the surface of salt solutions containing a range of concentrations of the herbicides for a standard period and mortalities determined.

Year 2 Samples of *P. minuta* from cotton-growing soils in northern NSW, and from areas not treated with herbicides will be obtained, cultured in the laboratory, and assessed for their response to herbicides.

Year 3 Preliminary experiments will be undertaken to examine the metabolism of appropriate herbicides by the insects to assess whether there may be any role for the insects in residue metabolism in cotton-growing soils.

STAFF:

This project is supervised by Dr. Edith Lees, Senior Lecturer in Agricultural Chemistry and the experimental work has been carried out by Mr. Eun-Kee Park, Ph.D student in the Department of Agricultural Chemistry and Soil Science, The University of Sydney, NSW 2006.

PROGRESS:

The experiments outlined for year 1 of the research plan have been carried out as detailed below.

The method used in experiments carried out to determine the toxicity of endosulfan was used to examine the toxicity of herbicides. Three batches of about 14 insects were placed on the surface of 2ml of sea salt solutions containing pesticides in sealed-lid glass vials. After 7 days, mortality was determined and the data were analysed using a probit program to determine LD₅₀ values (lethal dose to kill 50% of population of insect) for insecticides and herbicides.

Assay of the toxicity of α - and β -endosulfan, and endosulfan sulfate to *P. minuta* showed that α -endosulfan was more toxic than β -endosulfan and endosulfan sulfate. The LD₅₀ values determined were 0.01ppm for α -endosulfan, 0.05ppm for β -endosulfan and 0.06ppm for endosulfan sulfate.

Nine herbicides which are or have been used in cotton production, atrazine, diuron, fluometuron, metolachlor, paraquat, pendimethalin, prometryn, simazine and trifluralin, were used in this experiment. Atrazine and simazine are not now used in cotton production, but they are used in other agricultural systems and residues remain in the soil of many areas. The LD₅₀ values of the herbicides to *P. minuta* were determined and the results are shown in Table 1.

The results in Table 1 show that the herbicides are much less toxic than any of the endosulfan insecticides. The difference in toxicity of herbicides to Collembola may be related to the lipophilicity of the herbicide. Lipophilic compounds may penetrate the exoskeleton of an insect more easily than hydrophilic compounds. In these assays of a limited group of herbicides the more lipophilic herbicides were more toxic to Collembola, but further study will be needed to find out whether there is a relationship between toxicity to Collembola and lipophilicity of the herbicide.

Table 1

Herbicide	LD ₅₀ value (± range)	LD ₅₀ herbicides	Lipophilicity of herbicide (K _{ow})*
		LD ₅₀ α-endosulfan	
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