THE FATE OF ENDOSULFAN SPRAYED ON COTTON FOR INSECT CONTROL

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Introduction

Whenever chemicals are used to enhance profitable cotton production, there is a need for the industry to ensure that the following conditions are met:

1. The particular chemical is safe to use and does no permanent harm to the farmer's resource, i.e. the soils and water
2. There is no significant impact on the riverine environment at large, either in the short term or in the longer term.

The Cotton Research and Development Corporation (CRDC) is funding a comprehensive 3-year project to discover the environmental fate of endosulfan sprayed on cotton for insect control. Experience overseas suggests that endosulfan is in quite a different class to organochlorines like DDT, rarely if ever accumulating in soils or flora and fauna. However, apart from the routine testing performed by the manufacturers, there was no independent data on the fate of endosulfan under Australian conditions. This project was funded by CRDC to overcome this lack of data.

Features of the project

Now in its second year, the project aims to provide reliable data on whether environmental problems are liable to occur as a result of the continued use of endosulfan. Particular attention is being paid to the following aspects:

1. The rate of conversion of endosulfan to endosulfan sulphate and to other, less harmful forms of products in soil and water. This information, often summed up in the term "half-life", indicating the time taken for its concentration to fall to half the current value, is important in reaching a decision on whether endosulfan is stabilised in soil to the extent that it, like DDT, can accumulate as the years go by.
2. The likelihood that endosulfan sprayed on cotton can be transported from cotton fields to the environment at large and the means by which this transport may occur.

The procedures by which this is achieved include:

1. Periodic sampling of selected cotton fields. Over the 3-year period, more than 1000 soil samples will be examined and analysed for pesticide residues. From these data, a profile of the amount of endosulfan and products for each cotton field during the spraying season and through to the following season can be prepared. This data will allow conclusions about the potential for accumulation.

2. The analysis of each soil sample involves a lengthy, expensive procedure of organic solvent extraction, clean-up of the extracted material on alumina columns, concentration and chromatographic measurement using electron capture detection (ECD). Fortunately, the ECD technique is extremely sensitive and allows the detection and analysis of endosulfan down to concentrations in soil of 0.02 parts per million with ease.

3. To confirm the identity of individual peaks on the gas chromatogram, the technique of mass spectrometry is used. This procedure involves the preparation of a mass spectrum, given by fragments of the molecule in the peak, that provides a characteristic 'fingerprint' for each chemical substance. These 'fingerprints' for endosulfan and endosulfan sulphate are shown in Figure 1. Identification requires a sophisticated computer program, that searches a library of such material to perform comparisons for matching. A non-toxic product of endosulfan that we have observed by this technique in cotton-growing soils is endosulfan diol, a substance producing a mass spectrum that also differs only slightly from that given by endosulfan (see Figure 1).

Results

At this stage, the results are too preliminary in nature for firm conclusions. There is a need to obtain confirmation of data obtained in the first year and the final report will not be available before the end of 1993. However, the data from two cotton fields examined in the

Namoi Valley indicates that endosulfan degrades rapidly in these soils during the spraying season ("half-life" approximately 2 weeks) to endosulfan sulphate. The half-life of endosulfan in waters is much less than this, by almost a factor of 10 (Batley and Peters, 1990). This toxic product in turn is degraded in soil, but with a significantly longer half life of approximately 6 weeks. The results from the first season studied indicate that the rate of degradation of endosulfan and endosulfan sulphate exceeds the rate at which it is applied according to the recommendations of
the pyrethroid strategy. Therefore, there seems to be little or no likelihood of a long-term accumulation of toxic forms of endosulfan, in contrast to the case of DDT.

Currently, studies on the bio-transformations of endosulfan are also in progress. It would be preferable if endosulfan was converted in soil to endosulfan diol, a non-toxic form, rather than the equally toxic endosulfan sulphate (see Fig. 2). We have observed that endosulfan diol (see Guerin and Kennedy, 1990), but not sulphate, forms in aqueous systems in the absence of soil and we are at present studying conditions in which formation of the sulphate is favoured. Since the major contaminant of concern in the river system is endosulfan sulphate, the possibility of an alternative mode of transformation is of interest.

Conclusion

It would be difficult to overestimate the importance of endosulfan in the profitable growing of cotton in Australia. The highly successful pyrethroid strategy relies heavily on the use of endosulfan in the early stages of growth to prevent the development of resistance to insecticides by pests such as *Heliothis*. However, this importance alone could be insufficient to guarantee the continued availability of endosulfan to the cotton farmer. A decision on continued use will more likely be based on maximum residue limits (MRLs) set by agencies such as the NSW Environment Protection Authority (EPA) for river waters and the ability of the cotton industry to ensure that environmental contamination will be less than these MRLs allow. In fact, the most stringent of the limits being considered at present by authorities in Australia would be extremely difficult, probably impossible to meet, even under the most responsible conditions of endosulfan use by the industry.

A more rational approach would be one in which endosulfan would continue to be available for the time being, but under stricter guidelines of use and conditional on the meeting of goals set for reducing environmental contamination. This would require a response from the industry now in improved practices but would allow the gradual development of more benign alternatives to the use of endosulfan such as *Bacillus thuringiensis*. This would be in line with the CRDC's first two major objective

(CRDC, 1992) to "protect the crops against pests while reducing chemical dependence" and to "develop and promote adoption of environmentally sound, sustainable farming practices".

Currently, organisations such as the CRDC, the Irrigation Association of Australia, the Land and Water Resources Research and Development Corporation, the Murray-Darling Commission and NSW Department of Water Resources are engaged in a series of workshops and other activities designed to solve the problems of environmental contamination by pesticides and to provide guidance to cotton farmers. For example, NSW Water Resources since the 1990-91 season has been conducting an ongoing survey of the water quality in the northern rivers. This study has revealed that there is a significant seasonal problem of river water quality with respect to endosulfan and endosulfan sulphate residues. In this context, completion of this study on the fate of endosulfan sprayed on cotton for insect control eighteen months from now, will be timely in forming recommendations about the continued use of endosulfan.

References

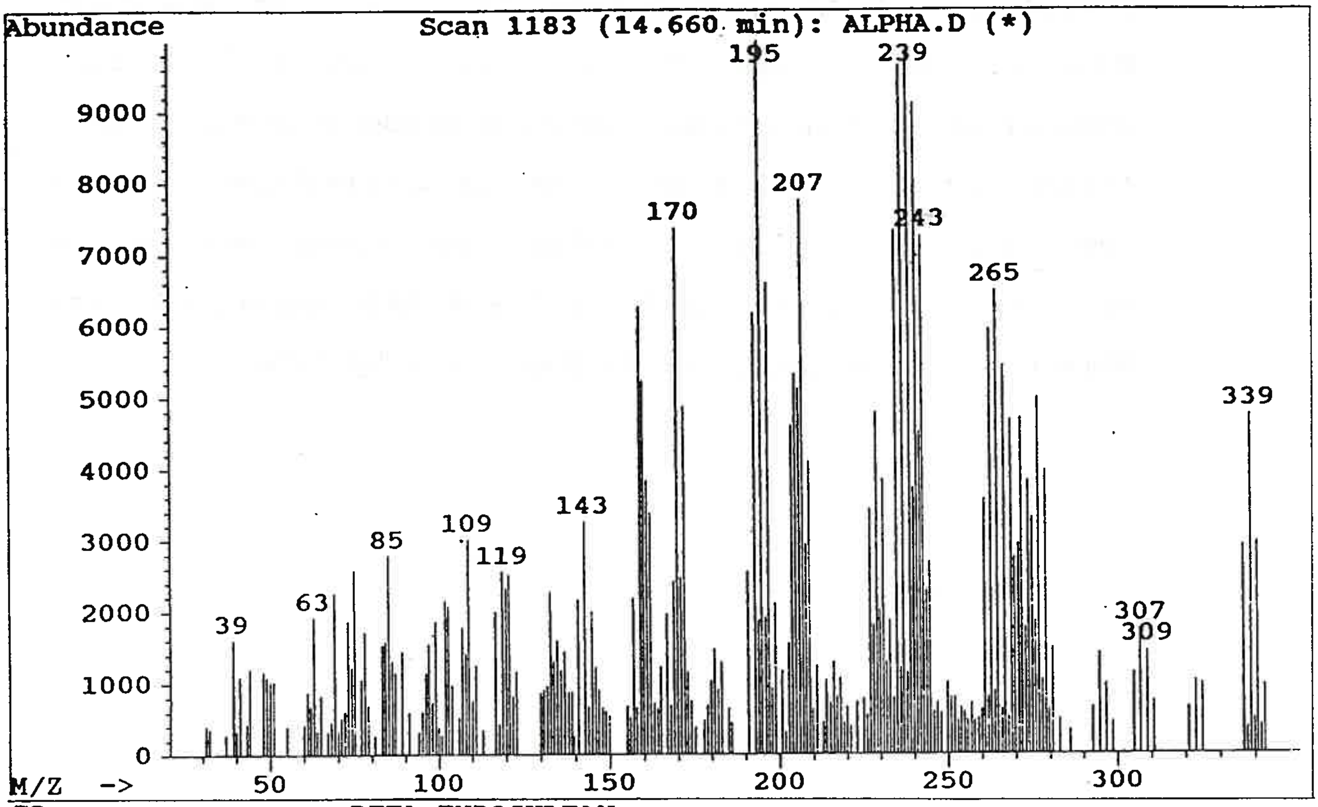
Guerin, T. and Kennedy, I.R. (1991) Biodegradation of endosulfan. *The Australian Cottongrower* 12,12-13.

Batley, G. and Peterson, S. (1991)

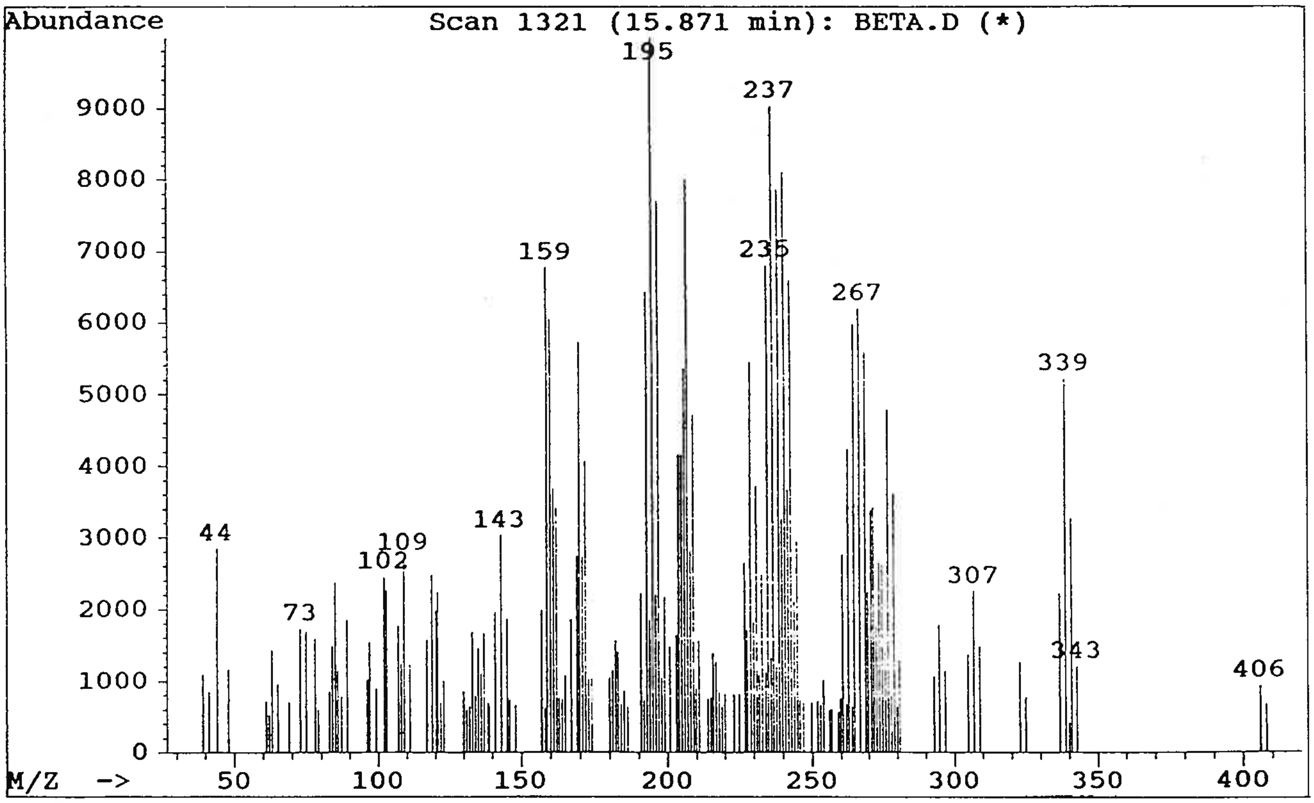
CRDC (1992) Cotton Research and Development Corporation1992 Handbook.

Figure 1: Mass spectrograms of endosulfan residues. Showing the 'finger-prints' for alpha and beta endosulfan, endosulfan sulphate and endosulfan diol. These 'finger-prints' allow accurate identification of each residue. A new Hewlett-Packard gas chromatograph-mass spectrometer has been purchased for this purpose by the University of Sydney, partly supported by CRDC.

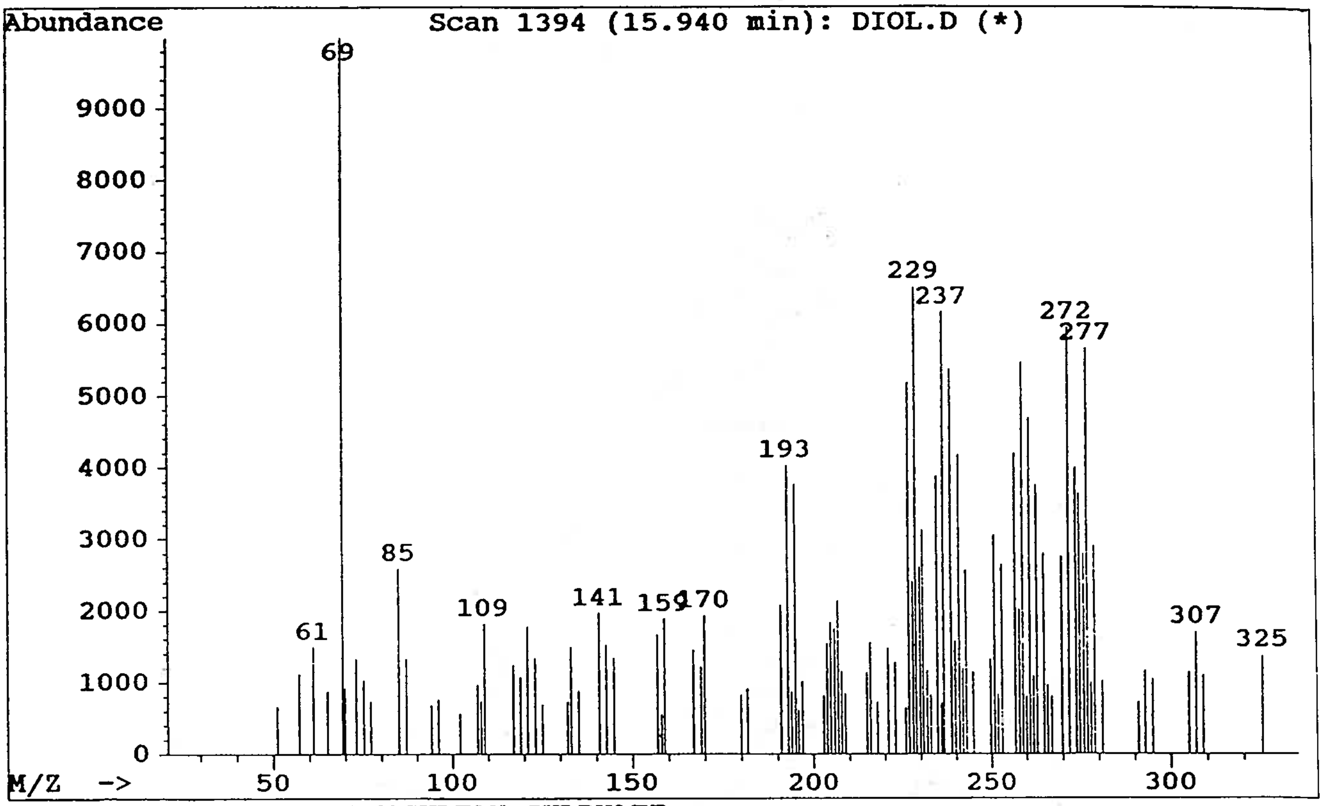
ID : ALPHA ENDOSULFAN



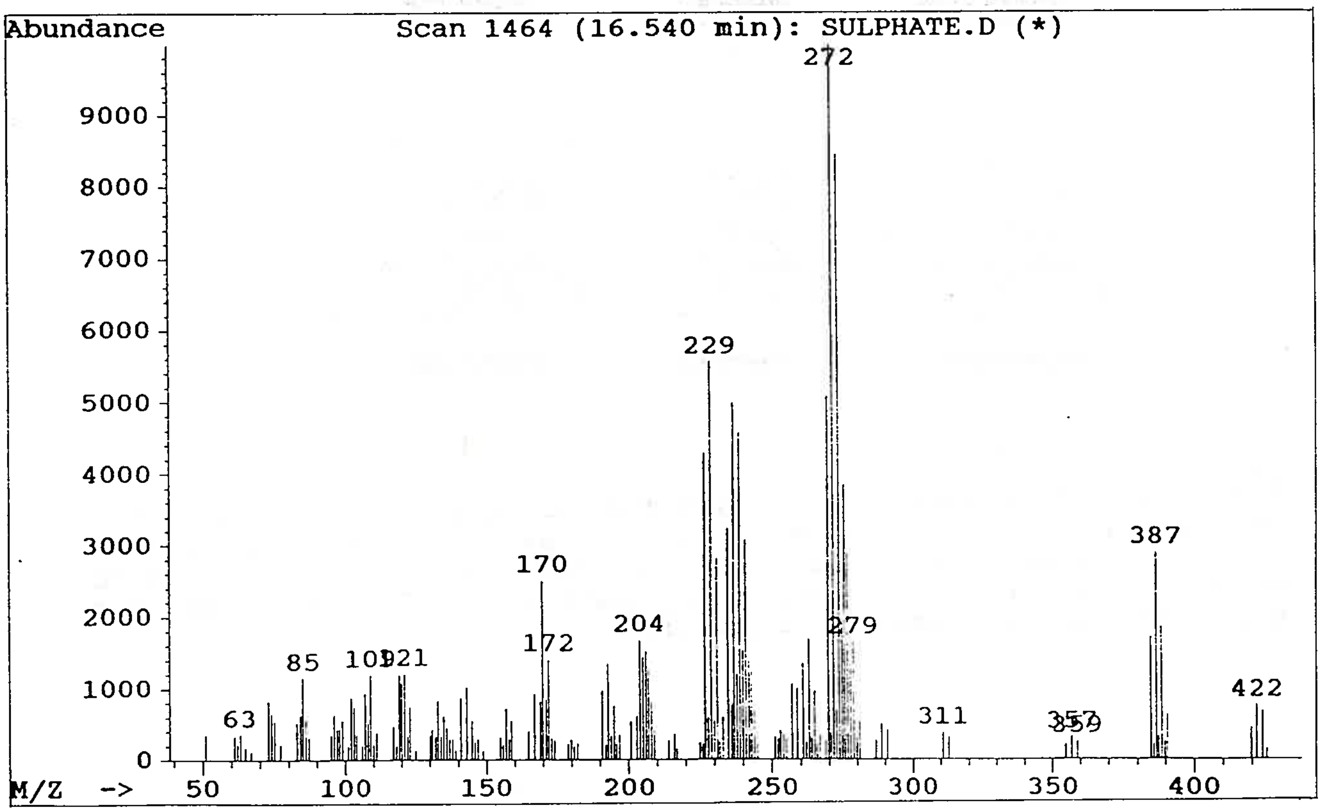
ID : BETA ENDOSULFAN



ID : ENDOSULFAN DIOL



ID : ENOSULFAN SULPHATE



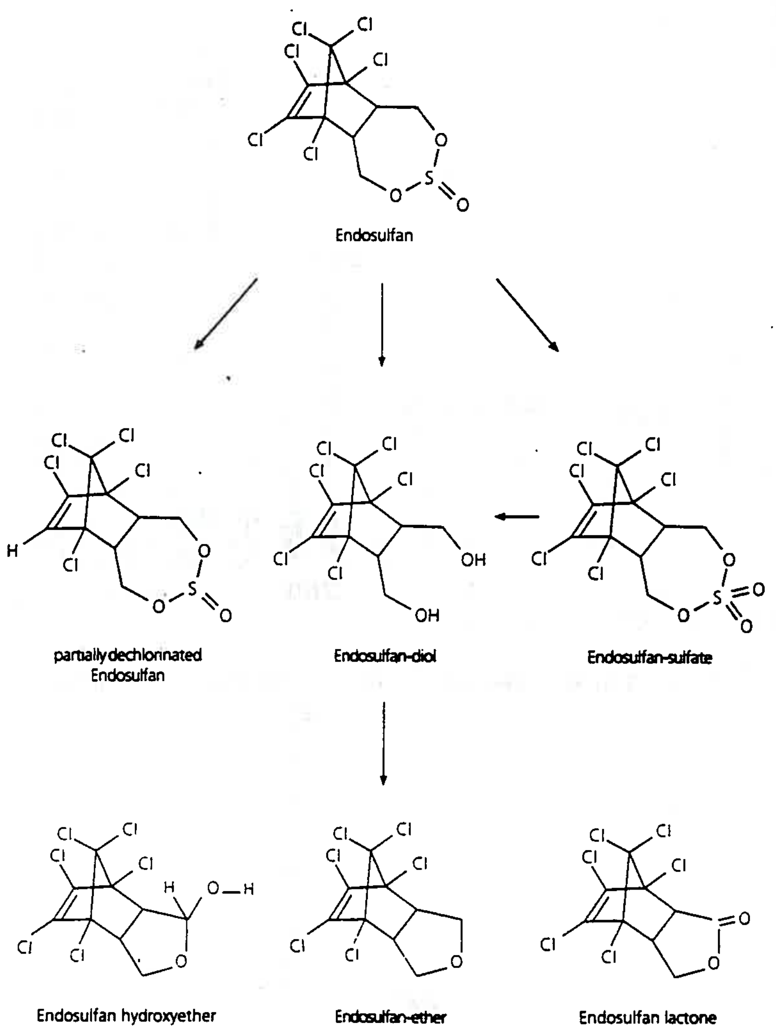


Figure 2: Conversion of endosulfan to endosulfan sulphate and endosulfan diol. A preferential formation of endosulfan diol would be desirable, since this is not toxic to fish. More research is required to discover whether the formation of more diol and less sulphate is feasible