

PESTICIDE MICROBIOLOGY

*Microbiological Aspects of Pesticide Behaviour
in the Environment*

Edited by

I. R. HILL

and

S. J. L. WRIGHT

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Foreword

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There is growing concern throughout the world at the way man is affecting, and often damaging, his environment. National and international agencies exist to monitor and control pollution of the air, of water and of the land. There is much popular debate of all environmental topics; this is often marred by error and emotion, but this may be better than complacency and apathy. In fact, where serious environmental damage has been demonstrated, striking improvements in environmental quality have generally occurred subsequently. Thus the air of most cities in developed countries, in Europe, America or Japan, is cleaner today than it was ten or twenty years ago. Though still polluted, many rivers in industrial areas are less filthy than they were in the past. We see that, where the facts are available, and where there is still the will to succeed, civilized man can enjoy the fruits of industrial progress and yet produce a cleaner world for himself and his descendants.

The control of all types of pollution can be expensive, and so it is wise to use resources sensibly to this end. This is not done when the dangers from, for instance, toxic chemicals are overestimated. In the past many useful substances have been denied to mankind because their possible disadvantages have been exaggerated. Control of new chemicals should be firmly based on a sound knowledge of their possible environmental effects. Such substances should not be widely used until their properties, including their toxicity and their stability, are properly understood. But the formulation of unnecessarily stringent precautions may be counterproductive; in some countries they have certainly delayed the introduction of efficient pesticides, and have thus prevented the control of agricultural and medical pests. Control should be based on knowledge, particularly of the sum total of

the biological effects, both beneficial and harmful, of substances like pesticides which are likely to enter our environment.

The use of pesticides illustrates well a dilemma which often faces modern man. No one can doubt that their use has made enormous contributions to agriculture and public health. Without pesticides world food supplies would be inadequate for the growing human population—even though this growth has been accelerated by the use of pesticides to conquer many of the major diseases which previously reduced population increase. However, this book is not concerned with this social problem, even though it is of major importance to man's ultimate survival on earth. This book is concerned with the ecological and environmental effects of the pesticides themselves.

Pesticides differ from most other substances which affect our environment in that they are deliberately dispersed by man for what he, the user, thinks are entirely desirable ends. Most other potential pollutants which are widely dispersed are the byproducts of industry and city living which man hopes he can get rid of, harmlessly, by dispersing and diluting them into the air, into rivers or into the sea. This process is usually successful. Many wastes are quickly diluted to harmless levels. However, others are not, hence many major developments in industrial and urban pollution control. These work by containing or destroying the dangerous substances which were previously discharged. But with pesticides the situation is quite different. If they are to be effective, they *must* be introduced into the environment in order to reach the target organisms—the pests—which they are designed to control.

Were a pesticide entirely specific in its action, so that only the target organism was killed, there would be no controversy about its use. Similarly, if it could be used so that the whole amount of the substance discharged reached the pest, and none spilled over to affect other organisms, it would not matter whether or not the poison was specific. But, though great progress has been made in producing more specific (or less unspecific) pesticides, for instance substances much more toxic to insects than to mammals, and though the efficiency of spraying has been greatly improved, there is still much room for improvement. Most pesticides can damage a wide range of organisms, both harmful and beneficial, for broad-spectrum pesticides are generally more useful and commercially viable than those suitable for only one pest. Even with the most efficient dispersal methods, more than 99% of most insecticides miss the bodies of the pests at which they are aimed. Herbicides are more effectively applied, but even with them there is substantial loss to the soil or onto non-target organisms. Therefore pesticides must obviously have important ecological effects, other than

those intended (that is, the control of the pests themselves) and these must be understood if these substances are to be used safely and efficiently.

Conservationists tend to stress the possible damage which may be done to wildlife by pesticides. In Britain in the late 1950s ornithologists were disturbed to find large numbers of dead birds strewn the countryside in early spring, victims of the use of aldrin and dieldrin seed dressings protecting cereals from attack by the Wheat Bulb Fly. It was shown that these chemicals were passed on to, and concentrated by, predators, which were themselves killed. There was great concern that small populations of slow breeding hawks would be exterminated. This proved to be a world wide problem, brought to public attention by the publication of books like Rachel Carson's *Silent Spring* in 1962, though scientists in many countries were working on the problem many years before this book was published, and have even taken effective action to reduce the harmful effects of these organochlorine insecticides by the voluntary ban of their use as seed dressing on spring-sown cereals in Britain.

The harmful side effects of pesticides on birds, and of herbicides drifting outside crops onto gardens or wild flowers may be easy to observe, and have generally been possible to control. However, many scientists have feared that the wide use of toxic chemicals may have more serious and more permanent effects of a less easily observable kind, by affecting microorganisms. This is one important subject which is discussed in this book. We are increasingly coming to realize that microorganisms, bacteria, fungi, algae, protozoa and small arthropods play important roles in soil, some related to the maintenance of its fertility. The destruction of beneficial bacteria, or shifts in the balance of populations of different species, may have marked effects on agricultural productivity. Soil science is a complex subject at all times, and the introduction of new and powerful chemicals with unknown effects could obviously make it even more complex. So the study of these effects is clearly of great importance.

On the other hand, it has been found that some microorganisms, though destroyed by particular pesticides, may flourish in the presence of others, and even use them as energy sources. The ecological problems relating to the persistence of toxic chemicals in the soil, with potential hazards to wildlife, can obviously be affected by the action of microorganisms which degrade pesticides and so prevent them from having such long-acting effects. This again is an important theme of some of the work described in this book.

Few of us can doubt that, with the growing world population, and the need for greater food production, pesticides will play an increas-

ingly important role in the future. Though we welcome developments in the non-chemical methods of pest control—including the use of parasites and predators, and the use of “genetic engineering” to make pests less viable—it is unlikely that these biological control methods will have anything like universal application. So we must get the greatest benefits and the least damage from the pesticides that are used. This book sets out to show how the knowledge to make this possible may be obtained, and how a better understanding of the relationships of microorganisms to the whole ecology of our environment may be realized. It will be found to be of value to microbiologists, for few can have first hand information on the whole range of topics covered. But it will be particularly useful to other biologists who wish to understand the role of microorganisms in this type of ecological problem which is obviously of such great economic importance in its relation to future problems of food production and public health.

June 1978

Preface

The interest of microbiologists in synthetic pesticidal chemicals extends far beyond the compounds which are aimed at microbial pests.

Why are so many microbiologists around the world now concerned with chemicals which are designed to control other, often totally unrelated, organisms? The answers lie in the ever-increasing global use of pesticides to sustain and enhance man's food supply, together with the remarkable ubiquity, diversity and numbers of the microbes whose collective activities are essential features of life on this planet. Microbes are present in all environmental situations in which pesticides are used and they will therefore encounter such man-made chemicals, however inadvertently, and probably react with them in some way. In simplest terms such interactions can be considered as (i) the action of microbes on pesticides and (ii) the action of pesticides on microbes. In reality the events are unlikely to be so clearly defined or isolated from the influence of other factors controlling the fate and activity of pesticides in the environment. We consider, however, that there is sufficient justification in the area of pesticide science for "Pesticide Microbiology". With the help of several authors we have attempted to produce a book reflecting our belief and which, hopefully, allows pesticide-microbe interactions to be seen in the wider environmental context.

Our intention has been to obtain a book which apart from serving as a reference source for workers already in the field, might also interest those who work in allied areas such as pesticide chemistry, toxicology and microbial ecology. We have also considered the growing number of undergraduate and post-graduate students whose courses and research embrace aspects of environmental microbiology, toxicology and the fate of xenobiotics. For these reasons we have included "introductory" chapters to give basic information on pesticides, microbial ecology and the environmental fate of pesticides. Overlap has been minimized, but retained where necessary for clarity or emphasis.

Of the many aspects of pesticide behaviour in the environment which currently receive scientific attention, there has been a notable acceleration in the microbiological field in industrial, Government-sponsored and academic research institutions globally. The vast

amount of information generated is widely dispersed in diverse scientific journals and books, in several languages. This book represents an attempt to bring at least some of this information together between two covers. Investigations in "Pesticide Microbiology" will increasingly require the skills and collaboration of microbiologists of different disciplines and inclinations. Dare we suggest that the subject can form a convenient bridge between the physiologists and ecologists in microbiology?

We thank the contributing authors, especially those who submitted manuscripts as originally requested in 1975 and have since been very patient whilst we pieced together the rest of the book. We gratefully acknowledge the guidance given by the staff at Academic Press and the work of the typists, especially Mrs. Rita Pratt and Mrs. Lorraine Thorne, who have competently dealt with the manuscripts at various stages. A special word of thanks go to Mrs. Glyn Pearce who so skilfully interpreted our intentions in producing the Figures in Chapter 3 and the design on the book's cover.

Finally, we sincerely thank our families for their great forbearance over the past years in which we have been occupied with the book. In particular we thank our wives, Lyn and Sue, for their considerable encouragement and help with some of the tasks involved. The book is dedicated to them.

I. R. HILL and S. J. L. WRIGHT
June 1978

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