Robert L. Metcalf
John J. McKelvey, Jr.

THE FUTURE FOR INSECTICIDES

NEEDS AND PROSPECTS

THE FUTURE FOR INSECTICIDES

Needs and Prospects

Proceedings of a Rockefeller Foundation Conference
Bellagio, Italy, April 22-27, 1974

Edited by

ROBERT L. METCALF
University of Illinois
Urbana, Illinois

and

JOHN J. McKELVEY JR.
Associate Director
for Agriculture Programs
The Rockefeller Foundation
New York, New York

A Wiley-Interscience Publication
JOHN WILEY & SONS
New York/London/Sydney/Toronto

Library of Congress Cataloging in Publication Data:

Main entry under title:
The future for insecticides.

(Advances in environmental science and technology; v. 6)
"A Wiley-Interscience publication."
Includes index.
1. Insecticides—Congresses. 2. Insecticides—Biodegradation—Congresses. I. Metcalf, Robert Lee, 1916- II. McKelvey, John J. III. Rockefeller Foundation. IV. Series. [DNLM: 1. Insecticides—Congresses. WA240 I59]

TD180.A38 vol. 6 [SB951.5] 668'.651 75-33224
ISBN 0-471-59860-7

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

Participants

DR. J. M. BARNES
MRC Toxicology Unit
Medical Research Council
Laboratories
Carshalton, Surrey, England

DR. WILLIAM S. BOWERS
Department of Entomology
New York State Agricultural
Experiment Station
Geneva, New York

DR. ALFRED M. BOYCE
College of Agriculture
University of California
Riverside, California

DR. GERRY T. BROOKS
Agricultural Research Council
Unit of Invertebrate Chemistry
and Physiology
The Chemical Laboratory
The University of Sussex
Brighton, Sussex, England

DR. JOHN E. CASIDA
Department of Entomological
Sciences
University of California
Berkeley, California

DR. MICHAEL ELLIOTT
Insecticides and Fungicides
Department
Rothamsted Experimental
Station
Harpenden, Herts, England

DR. T. ROY FUKUTO
Department of Entomology
University of California
Riverside, California

DR. WILLIAM F. FURTICK
FAO Regional Office for
Europe
Geneva, Switzerland

DR. W. KLEIN
Institut für Okologische Chemie
München, Germany

DR. CARLTON S. KOEHLER
Department of Entomological
Sciences
University of California
Berkeley, California

DR. MICHAEL LOCKE
Department of Zoology
The University of Western
Ontario
London, Ontario, Canada

DR. JOHN J. MCKELVEY, JR.
The Rockefeller Foundation
New York, New York

DR. ROBERT L. METCALF
Department of Entomology
University of Illinois
Urbana, Illinois

PROF. M. NAKAJIMA
Department of Agricultural Chemistry
Kyoto University
Kyoto, Japan

PROF. TOSHIO NARAHASHI
Department of Physiology and Pharmacology
Duke University Medical Center
Durham, North Carolina

DR. F. G. OPPENOORTH
Laboratory for Research on Insecticides
Wageningen, The Netherlands

DR. RALPH W. RICHARDSON
The Rockefeller Foundation
New York, New York

DR. WENDELL ROELOFS
Department of Entomology
New York State Agricultural Experiment Station
Geneva, New York

DR. RAY F. SMITH
Department of Entomological Sciences
University of California
Berkeley, California

DR. E. Y. SPENCER
Research Branch, Agriculture Canada
London, Ontario, Canada

DR. CHRISTOPHER F. WILKINSON
Cornell University
Ithaca, New York

DR. J. W. WRIGHT
World Health Organization
Geneva, Switzerland

INTRODUCTION TO THE SERIES

Advances in Environmental Science and Technology is a series of multiauthored books devoted to the study of the quality of the environment and to the technology of its conservation. Environmental sciences relate, therefore, to the chemical, physical, and biological changes in the environment through contamination or modification; to the physical nature and biological behavior of air, water, soil, food, and waste as they are affected by man's agricultural, industrial, and social activities; and to the application of science and technology to the control and improvement of environmental quality.

The deterioration of environmental quality, which began when man first assembled into villages and utilized fire, has existed as a serious problem since the industrial revolution. In the second half of the twentieth century, under the ever-increasing impacts of exponentially growing population and of industrializing society, environmental contamination of air, water, soil, and food has become a threat to the continued existence of many plant and animal communities of the ecosystem and may ultimately threaten the very survival of the human race.

It seems clear that if we are to preserve for future generations some semblance of the existing biological order and if we hope to improve on the deteriorating standards of urban public health, environmental sciences and technology must quickly come to play a dominant role in designing our social and industrial structure for tomorrow. Scientifically rigorous criteria of environmental quality must be developed and, based in part on these, realistic standards must be established, so that our technological progress can be tailored to meet such standards. Civilization will continue to require increasing amounts of fuel, transportation, industrial chemicals, fertilizers, pesticides, and countless other products, as well as to produce waste products of all descriptions. What is urgently needed is a total systems approach to modern civilization through which the pooled talents of scientists and engineers, in cooperation with

social scientists and the medical profession, can be focused on the development of order and equilibrium among the presently disparate segments of the human environment. Most of the skills and tools that are needed already exist. Surely a technology that has created manifold environmental problems is also capable of solving them. It is our hope that the series in Environmental Science and Technology will not only serve to make this challenge more explicit to the established professional but will also help to stimulate the student toward the career opportunities in this vital area.

Finally, the chapters in this series of Advances are written by experts in their respective disciplines, who also are involved with the broad scope of environmental science. As editors, we asked the authors to give their "points of view" on key questions; we were not concerned simply with literature surveys. They have responded in a gratifying manner with thoughtful and challenging statements on critical environmental problems.

To facilitate communications with our contributors and readers, we are including below our addresses and telephone numbers.

JAMES N. PITTS, JR., Editor
Statewide Air Pollution Research Center
University of California
Riverside, CA 92502
Telephone: (714) 787-4584

ROBERT L. METCALF, Editor
Environmental Studies Institute
Departments of Biology and Entomology
University of Illinois
Urbana-Champaign, IL 61801
Telephone: (217) 333-3649

ALAN C. LLOYD, Associate Editor
Statewide Air Pollution Research Center
University of California
Riverside, CA 92502
Telephone: (714) 787-3852

Preface

This book is rooted in a persistent concern which The Rockefeller Foundation and the profession of entomology share with the public: the need to improve the methods and the materials used for insect control in order to combat hunger, improve health, and provide an adequate quality of life for people. To address this issue specifically, the foundation first convened a meeting 6 years ago of entomologists versed in the entire gamut of methods employed for insect control. Four major programs grew out of that meeting, each multidisciplinary and multiuniversity in character. They deal with plant resistance to insect attack, juvenile hormones as sources of selective insecticides, pheromones for their potential impact on the population dynamics of insects, and biodegradable pesticides. These appeared to be the areas of research with strong prospects for yielding pioneering results to bring about effective and safe insect control.

Since pesticides constitute a group of chemicals that society cannot as yet do without, one obvious strategy for insect control is to accelerate the search for selective, biodegradable chemicals that will kill the target insect yet have little adverse effect on other, benign organisms in man's environment. A vital aspect of this strategy has been to enlarge the corps of young biochemists, toxicologists, entomologists, and related specialists capable of broadening the base of knowledge which is essential for designing selective biodegradable pesticides.

The chapters in this book point to the problems and show the recent progress that has been made in the development of such pesticides. But as the insecticides of today and those being fashioned for tomorrow lose their efficacy, or for other good reasons drop out of public favor, the never-ending search for new pesticides must continue.

In April 1974, The Rockefeller Foundation held a meeting at its Study and Conference Center in Bellagio for an updated assessment of the past, present, and future of the science and the art of the chemical approach to insect control. Leaders of the laboratories at which research is being conducted under the foundation's auspices met there with their colleagues from other laboratories. The essays embodied in this volume stem

directly from that meeting. They vary in style, content, and point of view expressed, but are bound to one another by common points of view, namely: (1) the urgency to continue to search for chemicals that in makeup may approach the ideal insecticide, and (2) the realization that the complexity and the magnitude of the task call for human capabilities and financial resources beyond those that any one man, laboratory, institution, or country may possess.

We hope that this book will advance a clear and rational understanding of what insecticides may be expected to do, what the real and imagined hazards of their use may be. The ideas the authors have set forth should stimulate creative students and staff to step up their research on biodegradable pesticides and encourage governments, international agencies, industry, and academic institutions to see their way clear cooperatively to amplify their support for the basic research that is so essential to the discovery of better, safer insecticides. We hope further that the information in this volume will prompt the public and private sectors of nations to seek ways and means to put to judicious use the wealth of material and information at hand for exploiting, in the best sense of the word, existing chemicals as insecticides while it paves the way for the acceptance, registration, and expeditious production of new chemicals for insect control.

Robert L. Metcalf
John J. McKelvey, Jr.

Acknowledgments

Many persons whose names do not appear in this book worked diligently and effectively to bring it into being. To them we are deeply grateful.

Dr. Carlton S. Koehler, Head of the Department of Entomology, Oregon State University and consultant to The Rockefeller Foundation, bore a major load in the production of this work. We are happy to express our appreciation to him for his signal contributions in the preparations leading to the conference held in Bellagio in 1974, in his participation in that conference, and in the work that followed the conference.

The editors are deeply indebted to Mrs. Dolores V. Tanno for her painstaking effort in final typing this volume of the Series.

INTERNATIONAL ASPECTS IN FOOD AND HEALTH

Contents

Insecticides in Food Production

WILLIAM R. FURTICK
The Food and Agriculture Organization of the United Nations
Rome, Italy

I. INTRODUCTION AND PAST SITUATION

The trends and extent of growth for the production and use of pesticides since World War II are documented for the industrial countries, particularly in North America, Western Europe, and Japan. The figures are less readily available for the centrally planned societies of East Europe. The overall amount of pesticides sold to the developing countries is reasonably reliable, but the figures for individual countries, and even more the uses made of the pesticides imported, are not readily and reliably available.

Nearly all pesticide production is limited at least in part to the industrialized countries of Europe, North America, and Japan. Although much of the parent pesticidal compounds is formulated into final commercial form in the developing countries—in less frequent cases some steps in the synthesis of the parent compound being carried out in a developing country —there is very little production that includes all steps of synthesis and final formulation.

Although the rate of growth in pesticide use in developing countries has tended to be higher in recent years than in the developed countries, the small base from which this growth started still results in the total tonnage of use by all developing countries to be small in comparison with the countries with highly developed modern agriculture. In 1970 the United States consumed 45% of all pesticide production, Western Europe 23%, Eastern Europe 13%, Japan 8%, and the developing countries 7%, with the rest in Australia and other developed countries.

When only the insecticide sector is examined, it is apparent that the trends in insecticide use compared to other pesticides is considerably different between the developing and developed countries. The relative growth rate between insecticides and other pesticides has been much less in the developed world compared with the developing world. In the developed

world, insecticides have declined in relative position among pesticides from being the dominant class of pesticide before 1960 to representing about one-third of total pesticide usage currently. This is in spite of large increases in total tonnage of insecticide use. The decline is primarily due to the rapid growth in the use of herbicides, which now represent the major portion of pesticides used and are still increasing in use at a more rapid rate than the others.

There is an indication that this trend may accelerate because of increased farmer substitution of herbicides for tillage due to much higher fuel and equipment costs and equipment shortages. Weed control is also of importance in preventing nutrient loss, and the increased prices and scarcity of fertilizer have a stimulating effect on weed control. The changing relationships between pesticides in the United States is illustrated in Table 1.

In the developing world, insecticides are the dominant class of pesticide used and are increasing at a rate that would appear to maintain their dominant position for some time to come. However, herbicide use is increasing rapidly where labor supply is depleted in many areas as a result of rapid urbanization.

International trends that have brought about greatly increased commodity prices in 1973 based on decreased stocks of basic agricultural commodities tended to further strengthen demand for pesticides. This was due to both the increase in crop acreage in the United States and the encouragement improved profitability gave to maximize production in the developed world. The result was to cause certain shortages of pesticides starting in 1974.

These same factors created pressure for increased food production in the developing countries, and the same trends were also apparent for large increases in pesticide, fertilizer, and machinery needs. This is clearly shown in Table 2.

The use pattern by crops for insecticides is fairly well known for the United States and some of the other developed countries, but is not well documented for the developing countries. These are illustrated in Table 3.

In the United States considerably more than half of all insecticide usage in agriculture is on cotton. Corn represents about 10% of all use. Of the fruit and vegetable crops, apples are one of the major crops for insecticide use. The breakdown in use by classes of compounds and projected levels in 1975 are found in Table 4.

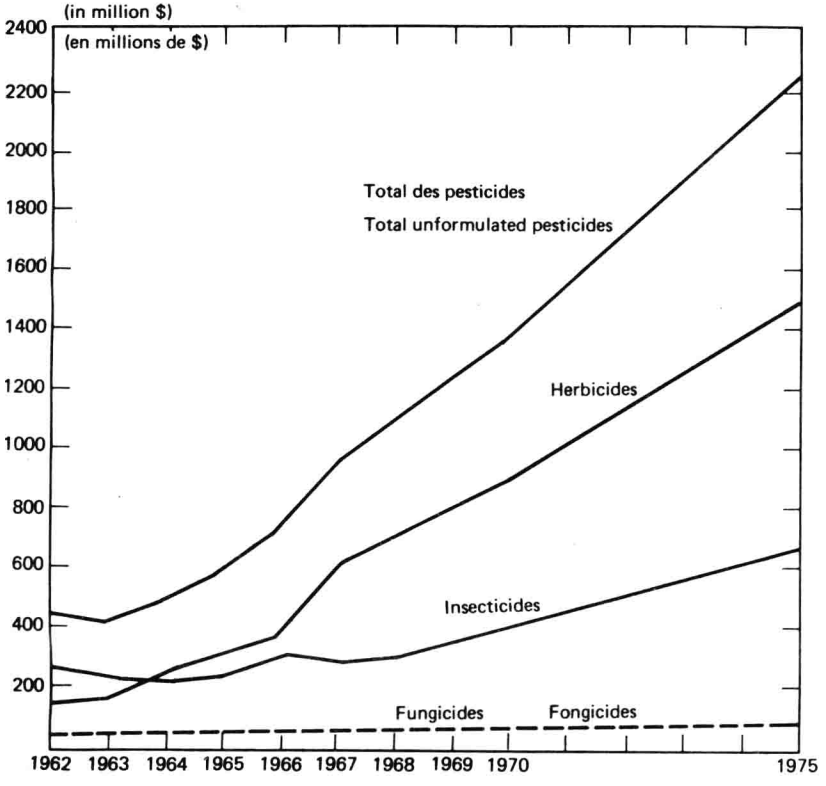
(in million $)
(en millions de $)
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
Total des pesticides
Total unformulated pesticides
Herbicides
Insecticides
Fungicides
Fongicides
1962 1963 1964 1965 1966 1967 1968 1969 1970
1975

TABLE 2. Insecticide Usage in 1972 and Projected Requirements for 1980 in Selected Developing Countries[a]

Country	OCs	OPs	Carbs	Other	Total	Projected Total
Philippines	482	203	267	12	924	24,499[b]
Indonesia	2,263	266	71	109	2,709	21,382
Thailand	2,932	637	56	421	4,046	15,956
India	18,000	3,175	3,000	160	24,335	54,500

[a]In metric tons of active ingredients. Based on 1973 FAQ/UNIDO Survey.

[b]Based on extremely successful Masagsae Programs.