英 100287

HERBICIDE
FUNGICIDE
INSECTICIDE
ACARICIDE

PESTICIDE SELECTIVITY

edited by

Joseph C. Street

（内部交流）

Pesticide Selectivity

edited by Joseph C. Street

Department of Animal Science
Utah State University
College of Agriculture
Logan, Utah

MARCEL DEKKER, INC. New York and Basel

COPYRIGHT © 1975 by MARCEL DEKKER, INC. ALL RIGHTS RESERVED.

Neither this book nor any part may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, microfilming, and recording, or by any information storage and retrieval system, without permission in writing from the publisher.

MARCEL DEKKER, INC.

270 Madison Avenue, New York, New York 10016

LIBRARY OF CONGRESS CATALOG CARD NUMBER: 75-12365

ISBN: 0-8247-6335-1

Current printing (last digit):
10 9 8 7 6 5 4 3 2 1

PRINTED IN THE UNITED STATES OF AMERICA

CONTRIBUTORS

Hollingworth, Robert M., Department of Entomology, Purdue University, West Lafayette, Indiana

Klingman, Glenn C., Plant Science Field Research, Eli Lilly and Company, Greenfield, Indiana

Knowles, Charles O., Department of Entomology, University of Missouri, Columbia, Missouri

Kohn, Gustave K.,* Chevron Chemical Company, Ortho Division, Richmond, California

Nakatsugawa, Tsutomu, Department of Entomology, State University College of Environmental Science and Forestry, Syracuse, New York

Siegel, Malcolm R., Department of Plant Pathology, University of Kentucky, Lexington, Kentucky

Stewart, Robert R., Department of Entomology, State University College of Environmental Science and Forestry, Syracuse, New York

Upchurch, Robert P.,** Agricultural Research Department, Monsanto Company, St. Louis, Missouri

Watson, T. F., Department of Entomology, University of Arizona, Tucson, Arizona

---

*Presently affiliated with the United Nations Industrial Development Organization, New Delhi, India

**Presently Chairman, Department of Plant Sciences, University of Arizona, Tuscon, Arizona

PREFACE

During recent years the intense public controversy over use of pesticides, revolving largely around preoccupation with the quality of environment, has frequently generated the suggestion that more narrowly selective pesticides should be developed. This view carries the implicit concept that the closer one approaches in use a one pest-one chemical pesticide balance, the greater the degree of safety to all other organisms. Minimum persistency is frequently coupled to this recipe for an environmentally acceptable pesticide, since the compound which self-destructs in the shortest period of time and is target-selective should be even more environmentally desirable.

The concept of insecticide selectivity was introduced to the scene by W. E. Ripper in 1944 as a "chemical that kills the uneconomic arthropod species and spares the economic species, namely, the pest's natural enemies."[1] Nicotine offered the earliest known example of such selectivity. Progress in developing such chemicals was not outstanding, however, so that by 1956 Ripper, in a classic review, could indicate only a few synthetic chemicals meeting his definition for selectivity.[2] Schradan was one found effective at that time. Ripper emphasized that

---

[1] W E. Ripper, Nature 153:448, 1944.

[2] W. E. Ripper, Ann. Rev. Entomology 1:403, 1956.

试读结束，需要全本PDF请购买 www.ertongbook.com

ecosystem stability depended on selective and partial control of the pest population by chemicals allowing the natural enemy population to stabilize on the reduced food supply represented by the pest numbers maintained near the economic threshold.

The developing physiological and biochemical understanding of insecticide toxicology soon provided an outline of the essential principles for selective insecticide action in relation to chemical properties of the compounds.[3] By the early sixties, therefore, it appeared that a rational search for development of selective insecticides should be possible. The desirability of such a search was then clearly in the public mind because of the forceful disclosures of problems with some broad-spectrum persistent insecticides as presented by Rachel Carson and other popular writers.

A clear statement of this philosophy became part of the U.S. federal research policy following the report in 1963 of the President's Science Advisory Committee on "Use of Pesticides."[4] That PSAC report stated, among others, the following recommendation: "In order to develop safer, more specific control of pests, it is recommended that government-sponsored programs continue to shift their emphasis from research on broad-spectrum chemicals to provide more support for research on (a) selectively toxic chemicals, (b) nonpersistent chemicals, (c) selective methods of application, and (d) nonchemical control methods such as attractants and the prevention of reproduction." The PSAC committee felt that production of safer, more specific, and less persistent pesticide chemicals did not represent an unreasonable goal and in this way encouraged the USDA and other to shift research programs toward development of increasingly specific controls, including selective chemicals.

---

[3] R. D. O'Brien, Adv. Pest Control Res. 4:75, 1961.

[4] President's Science Advisory Committee, Use of Pesticides, The White House, 1963.

After that date the rate of progress toward such goals was far from rapid with the result that the Mrak commission report to the Secretary of Health, Education, and Welfare in late 1969 recommended that "incentives should be provided to industry to encourage the development of safer chemicals with high target specificity, minimal environmental persistence, and few, if any, side effects on nontarget species."[5] By that time it was more clearly appreciated that the developmental costs of specific chemicals to be used selectively would be disproportionately high in relation to profits from the correspondingly low volume of sales for selective use. The Mrak committee thus perceived that high development costs would discourage research and development of selective pesticides without some form of incentive being provided.

Along the way it had been pointed out by E. F. Knipling, as well as others, that the development of selective systems for controlling pests cannot be accomplished without great effort and research.[6] "One of the chief advantages of a broad-spectrum pesticide is that a good one may lead to practical ways of controlling hundreds of pest species. In contrast, research on highly selective ways to control specific pests necessitates intensive research on every major pest. In many instances, the use of selective pest control measures will also mean higher cost to the grower or to the public."

The foregoing capsule history has been presented in terms of selective insecticides. Yet the various commissions and many other advocates made no distinctions and called for nonpersisting

---

[5] U. S. Dept. of Health, Education, and Welfare. Report of the Secretary's Commission on Pesticides and Their Relationship to Environmental Health.

[6] E. F. Knipling, in Pest Control Strategies for the Future, National Academy of Sciences, Washington, D. C., 1972.

selective pesticides in general, thereby including herbicides, fungicides, and all others.

This book developed from a symposium on Pesticide Selectivity held by the Division of Pesticide Chemistry, American Chemical Society, in Chicago, August 29, 1973. In presenting the symposium it was our modest intent to examine that generalization with respect to major classes of pesticides and attempt to establish a reasonable perspective. Is pest control with selective compounds uniformly feasible? Is the practical desirability of using narrowly selective herbicides similar to that for selective insecticides? What economic consequences might occur within agriculture and to the consumer through reliance on selective pesticides? Would we be following the best track in going for narrowly selective pesticides? Wintringham[7] raised this question in his recent review of insecticide selectivity in asking whether biodegradability, per se, is not a more significant quest? If economic compromising is necessary, should not this be the basis? These and related questions have been considered, if not firmly answered, in this book. The strategies found useful in obtaining selective action within classes of pesticides and progress toward achieving successful compounds are also discussed.

Joseph C. Street
Utah State University

[7] F. P. W. Winteringham, Ann. Rev. Entomology 14:409, 1969.

CONTENTS

Chapter 1

BROAD-SPECTRUM AND NARROW-SPECTRUM HERBICIDES--A NEED FOR BOTH

Glenn C. Klingman
Plant Science Field Research
Eli Lilly and Company
Greenfield, Indiana

The topic for this chapter has as its base Recommendation 11 from the Report of the Secretary of Health, Education, and Welfare Commission on Pesticides and their Relationship to Environmental Health, perhaps better known as the Mrak report {1969}. This recommendation is quoted in part as follows:

> Provide incentives to industry to encourage the development of more specific pest control chemicals. Incentives should be provided to industry to encourage the development of safer chemicals with high target specificity, minimal environmental persistence, and few, if any, side effects on nontarget species. Developmental costs will be disproportionately high in relation to profits from the lower volume of sales of more specific chemicals which will be used selectively. The high cost of development will discourage investments unless incentives are provided.

While not a part of this chapter, let us consider for a moment the first recommendation that "Incentives should be

试读结束，需要全本PDF请购买 www.ertongbook.com

provided to industry...." Industry does not need as "incentives" government subsidies or government assistance to do the needed research so long as it is not hampered by excessive regulatory restrictions and economic controls, and so long as it is allowed to compete in a relatively free market place. Industry does need as incentives an "appropriate climate" for the development of pesticides. This appropriate climate includes no weakening of patent procedures, and reasonable registration requirements involving meaningful research in the areas of toxicology and biological chemistry. Hazards to man and his environment must be related to real hazards, which must be researchable and provable. Through research, the exposure levels of the pesticide can be measured, and the hazards assessed. Can the applicator make the treatment without being exposed, or exposing others, or without effect to the environment, and is the food product free of harmful residues?

There is an area of government support that is needed--the research efforts and unbiased appraisal of pest control techniques by the USDA, University Research Programs, and Cooperative Extension Programs. Together with industry these programs have developed a highly productive, efficient agriculture. Food costs have been low in the past, partially at least, as a direct reflection of the success of this program.

A second recommendation concerns "the development of safer chemicals." This simple statement ignores the basic truth that most herbicides are safe and present little hazard in actual use. It would be foolhardy to say that we need "less safe" pesticides. It is not appropriate, however, to group all pesticides into one category. Each pesticide, indeed, each use of a pesticide, must be considered individually. Pesticides may be highly toxic, or far less toxic to man than common table salt.

Also, we should consider a third assumption in the Mrak recommendations--that we need "minimal environmental persistence." While possibly true with insecticides, it is not true of herbicides. Weed seeds, of one kind or another, germinate throughout a crop-growing season. If a crop is to be protected season long from weed competition, some persistence is required. For total vegetation control, such as on railroads, industrial sites, and roadsides, persistence is essential.

The important remaining part of Recommendation 11 from the Mrak report deals with favoring "narrow-spectrum pesticides" over "broad-spectrum pesticides." The remainder of this chapter, will consider the advantages and/or disadvantages of each, dealing only with herbicides.

Before proceeding, let us define the terms narrow-spectrum herbicide and broad-spectrum herbicide, taking into account that selectivity, which is mentioned by the Mrak report, is required for the use of a herbicide in a crop.

1. *Narrow-spectrum selective herbicide.* A chemical to which all plants are tolerant, except a very few. Thus, the herbicide can be applied to kill one plant or a very limited number without injury to all other plants. If such a herbicide were available, a weed such as cocklebur could be killed without injury to any crop and without effect on most other weeds. The fact of the matter is--we do not have narrow-spectrum selective herbicides on the market.
2. *Broad-spectrum selective herbicide.* A chemical that kills all plants, except a few. Thus, the herbicide can be applied to a crop (for example, cotton) and remove all other plants in the field. The chemical would be good only for cotton, but no other herbicide would be needed in cotton.

It may be of interest to note that cultivation was the first broad-spectrum method of weed control. Selective broad-sprectrum weed control was originally developed when plants were first planted in rows so that a horse could drag a heavy hoe between the rows.

Most selective herbicides fit the broad-spectrum definition. Table 1 shows several of the leading herbicides, the principal crops, and the number of weeds claimed specifically on labels or supplemental labels. Note that all of these herbicides are broad-spectrum both with reference to crops and weeds.

The Weed Science Society of America published a composite list of weeds by both common and botanical names {1971}. This list contains 2,060 different weed species with 87 percent of them broadleaved weeds, 11 percent grasses, and 2 percent sedges.

TABLE 1

Trade Name, Common Name, Principal Crops, and Number of Weeds Species Claimed on the Herbicide Label or Supplemental Labels

Trade name	Common name	Crop uses	Number of weed species claimed
Aatrex	atrazine	Corn, sorghum, sugarcane, plus 4 misc. uses	40
Eptam	EPTC	Beans, potatoes, plus 6 other crop uses	34
Karmex	diuron	Cotton, sugarcane, plus 26 misc. uses	48
Lasso	alachlor	Soybeans, corn, peanuts, cotton (restricted area)	23
Treflan	trifluralin	Cotton, soybeans, plus 34 misc. crops	27

Thus, if it were possible to develop a narrow-spectrum herbicide for each species, 2,060 different herbicides would be needed.

When asked about the number of weeds that are found in a usual cultivated crop, our field researchers, as would be expected, answered that the number would dramatically vary from field to field. However, when pressed for a specific number, there was agreement that there would be an average of 10 to 12 different, but important, weed species in most cultivated crop fields. The species, however, will vary considerably from field to field, crop to crop, and from one geographical area to another.

About 20 years ago, crabgrass (Digitaria sp.) was listed as the most serious weed in cultivated crop fields. It is interesting to note that crabgrass is one of the weeds controlled by all five of the important herbicides listed in Table 1. It is also interesting that crabgrass no longer is considered the number one weed. Farmers now have effective methods of controlling crabgrass in their crops.

Today, according to a number of surveys, the number one weed worldwide, is nutsedge or nutgrass (Cyperus rotundus L). Through the years, treatment of this weed has included the use of soil sterilant herbicides, 2,4-D, thiolcarbamate herbicides, heavy shade, and continuous clean cultivation for 2 years. However, the fact remains that none of these treatment "eradicates" the weed. With the above methods the farmer is able to control nutsedge so that he can grow a crop--but the weed quickly returns.

Let us consider then the practicality of developing a narrow-spectrum herbicide just for nutsedge control. Some of the first considerations would be the development costs and the size of the market, which will affect the cash flow of the company involved.

The average research cost of each new pesticide as given by M. B. Green at the Weed Science of America meetings {1973} was $5.5 million, starting from synthesis through early production of experimental permit materials. Fig. 1 illustrates the cash flow of a successful pesticide. Note that during the first 6 years it is all outgo. With marketing starting in the sixth year, the red ink in the ledger does not disappear until 10-1/3 years have passed.

Assume that you are research director for a company doing pesticide development work. To develop a nutsedge herbicide, you will need to consider a number of factors. For example, perhaps some other company finds a chemical equally effective on nutsedge control, one that also controls 25 other important crop weeds. In addition, suppose that a number of important crops are tolerant to the new chemical.

After considering the facts, few of us would recommend proceeding with a separate and independent research program aimed only at the control of nutsedge. A more likely route for the development of a successful nutsedge herbicide would be from ongoing herbicide screening tests conducted by industry. By including nutsedge in this screen, the chances are increased for finding such a herbicide. In this case, it is not likely that nutsedge control, alone, will need to bear the full research

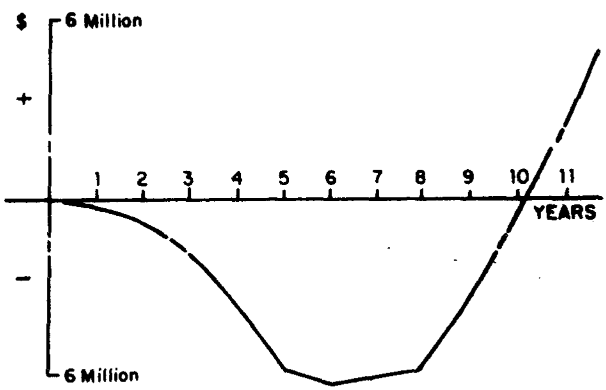

Fig. 1. Discounted cash flow of a successful pesticide.

cost of development--as it will be a broad-spectrum selective herbicide and will control other weeds in addition to nutsedge.

ENVIRONMENTAL POLLUTION EFFECTS

From a strictly environmental or pollution control point of view, let us consider narrow-spectrum vs. broad-spectrum herbicides. For discussion purposes, let us assume that there are six individual herbicides as shown in Table 2, used by soybean growers.

With the first five, one would probably need to use all five herbicides to efficiently grow soybeans. Thus, five times as much chemical could conceivably be going into the environment at a cost five times that had herbicide 6 been chosen. In addition, all the possible interactions would need to be studied, perhaps synergistic reactions as they relate to soybean tolerance or crop safety, crop residues, soil residues, efficacy of weed control, effect of the toxicology interactions on man, wildlife,

TABLE 2

The Effects, Tolerance, and Degree of Weed Control of Six Theoretical Herbicides Used in Soybean Cultivation

Herbicide	Controls	Fails to control	Tolerance	Spectrum of weed control
No. 1	Crabgrass	All other weeds	Tolerant	Narrow
No. 2	Pigweed	All other weeds	Tolerant	Narrow
No. 3	Foxtails	All other weeds	Tolerant	Narrow
No. 4	Lambsquarters	All other weeds	Tolerant	Narrow
No. 5	Johnson grass	All other weeds	Tolerant	Narrow
No. 6	All of the above plus many others	Has limited number of tolerant weeds	Tolerant	Broad

试读结束，需要全本PDF请购买 www.ertongbook.com