

# ANTIFUNGAL COMPOUNDS

VOLUME 1  
Discovery, Development, and Uses

*Edited by*

MALCOLM R. SIEGEL

HUGH D. SISLER

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## PREFACE

The need for fungicides is created by fungal activities detrimental to the welfare of mankind. As the bases for such destructive activities are identified, compounds are sought to control the fungi involved. Fungi had been identified as the basis of many problems a half century or more ago, but at that time very few fungicides had been found to control them. A great number of compounds have since been discovered, new methods of application have been developed, and new concepts on modes of action have evolved. At no time in the past has interest in fungicides been greater than during the current period of transition from the protective to the systemic fungicide.

A number of years have elapsed since a comprehensive coverage of fungicides appeared in two volumes edited by D. C. Torgeson (Fungicides: An Advanced Treatise, 1967). Since then, there have been marked advances in the development of systemic compounds, and a rising awareness of the toxicological hazards and the environmental impact of fungicides has evolved. With the advent of more selective fungicides, fungal resistance has emerged as a major problem. In this rapidly changing field, it is the purpose of this book and its companion volume to summarize and evaluate recent developments, to integrate these with significant developments of the past, and to attempt some projections into the future. We believe the various contributors to the volumes have achieved a reasonable measure of success for these goals.

The overall organization of the two books follows a biological—biochemical—ecological approach rather than one based on chemical class. However, individual authors have utilized the latter approach where it was most appropriate for their particular contribution.

This book, the first of the two volumes, focuses on the discovery, development, and use of fungicides and the problems associated therewith in plant pathology, medicine, wood preservation, and industry. The second volume considers fungicides according to their effects and their fate as they interact with biological, biochemical, and ecological systems.

We are grateful to the many authors whose efforts have made these volumes possible. We wish to thank Carolyn Siegel, Patricia Sisler, Libbie Jones, Debby Owen, and Jeanne Kelleher for generous assistance in the preparation of the manuscripts.

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## CONTENTS OF VOLUME 2

### SOIL-FUNGICIDE INTERACTIONS

Donald D. Kaufman

### SYSTEMIC FUNGICIDES: THEORY, UPTAKE, AND TRANSLOCATION

L. V. Edgington and Carol A. Peterson

### BIOLOGICAL CONVERSION OF FUNGICIDES IN PLANTS AND MICROORGANISMS

A. Kaars Sijpesteijn, H. M. Dekhuijzen, and J. W. Vonk

### BIOLOGICAL CONVERSIONS OF FUNGICIDES IN ANIMALS

Gaylord D. Paulson

### NONBIOLOGICAL CONVERSIONS OF FUNGICIDES

David Woodcock

### PERMEATION AND MIGRATION OF FUNGICIDES IN FUNGAL CELLS

Donald V. Richmond

### INHIBITION OF FUNGAL CELL WALL SYNTHESIS AND CELL MEMBRANE FUNCTION

Tomamasa Misato and Kazuo Kakiki

### EFFECT OF FUNGICIDES ON ENERGY PRODUCTION AND INTERMEDIARY METABOLISM

H. Lyr

### INHIBITORS OF LIPID SYNTHESIS

Nancy N. Ragsdale

### EFFECT OF FUNGICIDES ON NUCLEIC ACID SYNTHESIS AND NUCLEAR FUNCTION

J. Dekker

EFFECT OF FUNGICIDES ON PROTEIN SYNTHESIS

Malcolm R. Siegel

DEVELOPMENT OF FUNGAL RESISTANCE TO FUNGICIDES

S. G. Georgopoulos

ANTIFUNGAL COMPOUNDS ASSOCIATED WITH DISEASE RESISTANCE  
IN PLANTS

Joseph Kuć and Louis Shain

TOXICOLOGICAL ASPECTS OF FUNGICIDES

Lawrence Fishbein

## CONTENTS

Preface .....	iii
Contributors .....	xi
Contents of Volume 2 .....	xv
Chapter 1. HISTORY OF FUNGICIDES .....	1
Elvins Y. Spencer	
I. Introduction .....	2
II. Plant Protectants up to 1882 .....	3
III. Plant Protectants, 1882-1934 .....	4
IV. Plant Protectants, 1934-1964 .....	4
V. Plant Protectants, 1964-1975 .....	7
VI. Resistance .....	11
VII. Screening Methods .....	12
VIII. Future Developments .....	13
IX. Environmental Effect .....	13
X. Analytical Methods and Residues .....	14
XI. Conclusion .....	14
References .....	14
Chapter 2. FUNGICIDES IN PERSPECTIVE .....	19
William E. Fry	
I. Introduction .....	19
II. Strategies of Plant Disease Control .....	20
III. Pest Management, Diseases, and Fungicides .....	30
IV. Summary .....	42
References .....	42

Chapter 3.	DETECTING POTENTIAL PROTECTIVE AND SYSTEMIC ANTIFUNGAL COMPOUNDS .....	51
	E. Neil Pelletier	
	I. Introduction .....	52
	II. Criteria for Selecting Test Methods .....	53
	III. In Vitro Tests .....	54
	IV. In Vivo Tests .....	57
	V. Seed and Soil Treatment Fungicide Tests .....	60
	VI. From Promise to Practical Use .....	64
	References .....	64
Chapter 4.	DEVELOPMENT OF CHEMICALS FOR PLANT DISEASE CONTROL .....	69
	Charles J. Delp	
	I. Development Today: A Current Example .....	70
	II. Chemical Considerations .....	74
	III. Marketing Considerations .....	77
	IV. Biological Considerations .....	80
	V. Development Tomorrow .....	85
	References .....	87
Chapter 5.	THE THEORY AND PRACTICE OF APPLYING FOLIAR FUNGICIDES .....	89
	E. Evans	
	I. Introduction .....	90
	II. Formulation of Foliar Fungicides .....	91
	III. Spray-cloud Formation .....	95
	IV. Retention of Sprays on Crop Plants .....	102
	V. The Fate of Spray Liquid .....	106
	VI. Some Practical Aspects of Applying Foliar Fungicides .....	109
	VII. Summary .....	113
	References .....	114
Chapter 6.	CONTROL OF SEED AND SOILBORNE PLANT DISEASES .....	117
	R. Rodriguez-Kabana, Paul A. Backman, and Elroy A. Curl	
	I. Introduction .....	118
	II. Ecological Considerations .....	118
	III. Soil Treatment .....	130

IV. Seed Treatment . . . . .	146
References . . . . .	152
<b>Chapter 7. CONTROL OF VASCULAR PATHOGENS . . . . .</b>	<b>163</b>
Donald C. Erwin	
I. Introduction . . . . .	163
II. Strategy of Control . . . . .	166
III. Chemical Control . . . . .	171
IV. Discussion . . . . .	214
References . . . . .	216
<b>Chapter 8. CONTROL OF FOLIAGE AND FRUIT DISEASES . . . . .</b>	<b>225</b>
Zvi Solel	
I. Importance of Foliage and Fruit Diseases . . . . .	226
II. Intrinsic Factors Influencing the Activity of Foliage and Fruit Fungicides . . . . .	227
III. Methodology of Fungicide Application . . . . .	241
IV. Timing of Fungicidal Treatment . . . . .	249
V. Ideas for the Future . . . . .	261
References . . . . .	262
<b>Chapter 9. CONTROL OF POSTHARVEST DISEASES . . . . .</b>	<b>269</b>
Joseph W. Eckert	
I. Introduction . . . . .	270
II. Development of Postharvest Diseases . . . . .	275
III. Strategy of Postharvest Disease Control . . . . .	280
IV. Methods for Applying Postharvest Treatments . . . . .	294
V. Properties and Applications of Specific Fungicides . . . . .	306
VI. Current Problems and Trends in Postharvest Disease Control . . . . .	336
References . . . . .	337
<b>Chapter 10. FUNGICIDAL CONTROL OF PLANT DISEASES IN THE TROPICS . . . . .</b>	<b>353</b>
R. H. Stover	
I. Introduction . . . . .	354
II. Use of Fungicide in the Tropics . . . . .	354
III. Tropical Crops Requiring Fungicide Treatment . . . . .	357
IV. Formulations . . . . .	364
V. Application Equipment . . . . .	365

VI. Epidemiological Considerations:	
When to Spray . . . . .	366
VII. Economical Considerations . . . . .	367
VIII. Conclusion . . . . .	368
References . . . . .	368
 Chapter 11. FUNGICIDES IN INDUSTRY . . . . .	371
Charles C. Yeager	
I. Introduction . . . . .	372
II. Textile Fungicides . . . . .	373
III. Plastics Fungicides . . . . .	381
IV. Paint Fungicides . . . . .	387
V. Paper Fungicides . . . . .	388
VI. Rubber Fungicides . . . . .	389
VII. Fungicides for Adhesives and Emulsion Polymers . . . . .	390
VIII. Miscellaneous Fungicide Applications . . . . .	391
IX. Conclusion . . . . .	394
References . . . . .	394
 Chapter 12. FUNGICIDES IN WOOD PRESERVATION . . . . .	397
Michael P. Levi	
I. Introduction . . . . .	398
II. Characteristics of Wood-inhabiting Fungi . . . . .	399
III. Nonfungicidal Control Techniques . . . . .	402
IV. Fungicides in Wood Preservation . . . . .	404
V. Application Methods . . . . .	422
References . . . . .	432
 Chapter 13. FUNGICIDES IN MEDICINE . . . . .	437
Smith Shadomy, H. Jean Shadomy, and Gerald E. Wagner	
I. Introduction . . . . .	437
II. The Human Mycoses . . . . .	438
III. Medicinal Fungicides . . . . .	449
IV. Laboratory Studies . . . . .	458
References . . . . .	459
 Chapter 14. RESIDUE ANALYSIS . . . . .	463
H. P. Burchfield and Eleanor E. Storrs	
I. Introduction . . . . .	463
II. Extraction and Cleanup . . . . .	464

III. Measurement of Residues . . . . .	465
IV. Specific Methods . . . . .	469
References . . . . .	501
Chapter 15. SAFE AND RESPONSIBLE USE OF FUNGICIDES . . . .	507
William C. von Meyer and René J. Lacoste	
I. Introduction . . . . .	508
II. The Need for Safe Handling and Use of Pesticides . . . . .	509
III. Principles of Responsibility and Safety . . . . .	516
IV. Research on Product Safety . . . . .	522
V. The Future . . . . .	526
References . . . . .	528
Chapter 16. FUNGICIDES: PROBLEMS AND PROSPECTS . . . . .	531
Hugh D. Sisler	
I. Introduction . . . . .	532
II. Protective Fungicides . . . . .	532
III. Systemic Fungicides . . . . .	533
IV. Modification of Host Susceptibility . . . . .	535
V. Modification of Pathogenicity . . . . .	537
VI. Resistance . . . . .	539
VII. Toxicological and Environmental Hazards . . . . .	543
VIII. Recent Developments . . . . .	544
References . . . . .	544
Author Index . . . . .	549
Subject Index . . . . .	589

## Chapter 1

### HISTORY OF FUNGICIDES

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I. INTRODUCTION .....	2
II. PLANT PROTECTANTS UP TO 1882 .....	3
III. PLANT PROTECTANTS, 1882-1934 .....	4
IV. PLANT PROTECTANTS, 1934-1964 .....	4
A. Dithiocarbamates .....	5
B. Quinones .....	5
C. Ethylenebisdithiocarbamates .....	5
D. Trichloromethylthiocarboximides .....	6
E. Miscellaneous Protectant Fungicides .....	6
F. Antibiotics .....	6
V. PLANT PROTECTANTS, 1964-1975 .....	7
A. Systemics .....	7
B. New Protectant Fungicides .....	10
VI. RESISTANCE .....	11
VII. SCREENING METHODS .....	12
VIII. FUTURE DEVELOPMENTS .....	13
IX. ENVIRONMENTAL EFFECT .....	13
X. ANALYTICAL METHODS AND RESIDUES .....	14
XI. CONCLUSION .....	14
REFERENCES .....	14



## I. INTRODUCTION

A history of fungicides would not be complete and would lack perspective without some reference to ancient and medieval plant pathology. This has recently been ably reviewed by Orlob [1]. Early plant pathology was not so much concerned with any particular disorder as it was with the overall success of the crop. Very often plant diseases were attributed to supernatural and magical causes, and it is not surprising that protective measures were based on the same conceptions resulting in magical practices and rituals. The most valuable contribution to early plant pathology came from astronomy and meteorology where certain disease developments were correlated with atmospheric conditions.

A survey of the developments in methods of plant protection indicates definite eras. If one ignores the magical practices of ancient times, one might cite sulfur as the fungicide marking the first era from unrecorded times to 1882. This was followed by the copper era from 1882 to 1934 which then led into the initial organic fungicide era. The latter era coincided with similar major expansion in organic insecticides, herbicides, and antibiotics. It is of interest to note that in this development systemic insecticides appeared very early without a parallel one in fungicides. Although much effort has been devoted to the search for and development of systemic fungicides, it was noted in 1967 that there is "... no outstanding commercial control of plant diseases by systemic fungicides, interest continues and the practical solution is only a matter of time" (Ref. 2, p. 25). Almost simultaneously with that statement, a publication appeared on the systemic fungicidal activity of 1,4-oxathiin derivatives [3] of which two have since been commercially developed. This marked the beginning of a new "sub era" of organic fungicides, namely systemic fungicides, several of which are already in industrial production with more at the developmental stage.

The presystemic fungicides are largely protectants, the initial ones being inorganic like sulfur and various forms of copper, with Bordeaux mixture being the most common form. Then in 1934, the modern era of organic fungicides emerged with the discovery of the fungicidal properties of the dithiocarbamates [4]. They do not penetrate the plant cuticle and therefore are usually not effective in eradicating established infection. Application is by foliar spray, so that complete coverage is required for protection and, as new growth is vulnerable to infection, spraying has to be repeated.

For protectant fungicides, selective accumulation by the spores plays a dominant role in their toxicity [5]. Thus very high concentrations of fungicide are required. For a majority of the protectants  $ED_{50}$  values lie within the range of 100-100,000  $\mu\text{g/g}$  spore, which is greatly in excess of toxic ratios normally considered for insecticides [6]. They show a wide range of activity against fungi as they react without specificity at cell-receptor sites. Thus the continuous application in the field of these relatively low-toxicity fungicides has rarely resulted in the appearance of resistant strains of plant pathogens.