



# PLANT DISEASE HANDBOOK

*by*

CYNTHIA WESTCOTT

*"The Plant Doctor"*



---

SECOND PRINTING

---

D. VAN NOSTRAND COMPANY, INC.

PRINCETON, NEW JERSEY

TORONTO

NEW YORK

LONDON

D. VAN NOSTRAND COMPANY, INC.  
120 Alexander St., Princeton, New Jersey  
257 Fourth Avenue, New York 3, New York  
25 Hollinger Rd., Toronto 16, Canada  
Macmillan & Co., Ltd., St. Martin's St., London, W.C. 2, England

*All correspondence should be addressed to the  
principal office of the company at Princeton, N. J.*

COPYRIGHT, 1950, BY  
D. VAN NOSTRAND COMPANY, INC.

Published simultaneously in Canada by  
D. VAN NOSTRAND COMPANY (Canada), Ltd.

---

*All Rights Reserved*

*This book, or any parts thereof, may not be  
reproduced in any form without written per-  
mission from the author and the publisher.*

---

*First Printing, March 1950  
Reprinted December 1955*

PRINTED IN THE UNITED STATES OF AMERICA



## PREFACE

The *Plant Disease Handbook* was designed as a companion volume to *The Gardener's Bug Book*, a reference book for professional and amateur gardeners and those who advise them. It turns out to be a formidable tome, and a hybrid to boot, composed of purely technical information crossed with admonitions to the layman. The result is neither a comforting bedside volume for the first-year gardener nor a treatise for the specialist in any one field. It is a compendium (and that word means inclusion within *small* compass of a *large* subject) of available information on diseases of plants grown in gardens or in the home in continental United States. It includes some references to Alaska and the subtropical region of southern Florida, but excludes the purely tropical problems of Hawaii, the Canal Zone, and Puerto Rico. It includes florists' crops grown for home decoration and native plants sometimes grown in wild gardens, but excludes cotton, wheat, and other field crops.

This information is filtered through, and somewhat colored by, my own experience. Once upon a time I was a normal plant pathologist. Since 1933 I have been a practicing plant physician called upon to minister to private garden patients and expected to act as a liaison agent between the university and the gardening public. When requests for free information get so numerous I cannot salvage enough time to take care of the paying patients I write a book—first, to save my time in finding the answers, second, to encourage a few gardeners to look up the answers for themselves.

*The Plant Doctor*, published in 1937, was quickly written, for it was based entirely on the doctor's casebook and limited to diseases and pests found most commonly in northeastern gardens. The day that galley proofs went back to the printer I set out to discover how many of my observations were true for the rest of the country. This handbook has been in the making ever since. While New Jersey gardens sleep in the winter the Ford and I have wandered thousands of miles. I have visited tiny backyard gardens and large estates, public gardens and parks, commercial nurseries and greenhouses, universities and experiment stations, from New England to Florida, from New York to California. To cite individually the people who have opened their homes and gardens, answered questions, provided bulletins and reprints, and shown experiments in progress, would fill many pages. I can give here only a collective thank-you. Garden visiting is by no means a sunny weather proposition and I am particularly grateful to the indefatigable souls who trudged around with me in the cloudbursts of "sunny" Florida and California, in Texas snow-

storms, Louisiana icestorms, Iowa windstorms, and Virginia high tides. We who garden in the heat and humidity of New Jersey summers have no monopoly on bad weather.

Superimposed on such a background is the literature summary presented here, arranged for finger-tip reference. I hope that it will prove useful not only to gardeners but to those who serve them—the landscape architects who design their plantings, the florists and nurserymen who grow their plants and cut-flowers, the dealers who supply their seeds and fungicides, the arborists who care for their trees and shrubs, the county agents who answer their questions, and the plant pathologists who diagnose their diseased specimens.

The charge has been made that plant pathologists can tell you what a disease is but seldom what to do about it except to "Remove diseased plants or parts; rake up and burn fallen leaves." The charge has been made against this handbook, reviewed in manuscript, that too many possible control measures are offered without indication of the best. I plead guilty on both counts. We really know very little about disease control in home gardens and, while sanitary measures do not always lessen the incidence of disease, they work fairly well in some instances. In no instance is it possible for me to recommend a single chemical that will control a given disease in all parts of the country in all seasons without plant injury. I can make no such recommendation for rose diseases, and I have tested fungicides on roses for a quarter of a century. The most I can say is that a certain spray is expedient in the conditions under which I practice. I can cite numerous instances where the same chemical applied in the same dilution on the same dates controlled black spot in one rose garden and not in the one across the street.

The use of chemicals by amateurs is hazardous in any event. Many of the control measures mentioned have been developed for professional growers and in some cases should be left to them. It is far better for the grower to sell a healthy plant than for the gardener to try to cure a sick one. Without implying that any reputable nurseryman would deliberately sell a diseased plant, I think that there is room for a good deal of education. For that reason disease symptoms which remain constant are given more prominence than control measures which are constantly changing. The grower must learn not to sell, and the gardener to reject, dangerously diseased plants. While scouting for azalea petal blight in Georgia some years ago I met a conscientious nurseryman who said he would certainly like to see that disease and learn to recognize it. I asked him what he thought was the matter with the row of azaleas he was standing by. "That? Oh, that's just weather! We had rain a couple of days ago and the blossoms all collapsed." The blossoms had collapsed from the petal blight, encouraged by the weather.

On the other hand, I found it equally difficult to persuade a park superintendent that his azaleas were actually suffering from drought and not petal blight. Because few gardeners realize the importance of distinguishing be-

tween a disease caused by a living organism and that caused by an unfavorable environmental influence I have stressed the latter in the section on Physiological Diseases and have included spray injuries under the same heading.

The backbone of the handbook is the list of diseases under host plants in Chapter 5. Credit for this section goes almost entirely to Freeman Weiss whose *Check List Revision, Diseases of Economic Plants of the United States* has been published in installments, from 1940 to 1949, in the *Plant Disease Reporter*, issued by The Plant Disease Survey, Division of Mycology and Disease Survey, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, United States Department of Agriculture. A very particular thank-you goes to Dr. Weiss, not only for permission to adapt the check list for my purposes but for painstakingly going over Chapter 5 and making many suggestions as to nomenclature. The record of states where diseases are found is compiled by The Plant Disease Survey from reports by collaborators all over the country. My grateful appreciation goes to these collaborators and to Paul R. Miller, head of the Survey. Dr. Miller has read the entire manuscript and made helpful suggestions.

The bibliography must stand as my acknowledgment of debt to many authors. A great many others, uncited, have also provided information.

The decision to sandwich in classification of the pathogen along with the usual description of the disease (for the benefit of people with a microscope and most especially myself) has added many unexpected months to the preparation of the manuscript. During the years of working in gardens I had forgotten that names could be so baffling and that classifications changed almost as rapidly as control measures. Authorities used in naming bacteria, fungi, and viruses are given in the text.

Finding no consistency in present-day usage of host names—e.g. horsechestnut, horse-chestnut and horse chestnut, mountain ash, mountain-ash and mountain-ash—I have taken the middle-of-the-road policy and followed *Hortus Second*. The hyphen is used to designate plants which are not what the name implies. That is, mountain-ash (*Sorbus*) is not a true ash (*Fraxinus*) nor horse-chestnut (*Aesculus*) a chestnut (*Castanea*). This distinction seems useful in dealing with diseases, for they are often confined to a single genus or family.

The photographs are of material collected in doctoring gardens or on cross-country jaunts and are intended to emphasize the more common home garden problems. Many were taken by my former assistant, Lacelle Stites, who deserves special thanks. The drawings are diagrams adapted from various sources.

It is easy enough to start a book on plant disease. It is impossible to finish it. Every garden visited, every meeting attended, every journal read, means additions, deletions, and corrections. So I chop it off, unfinished, while the river of knowledge keeps rolling along.

CYNTHIA WESTCOTT

Glen Ridge, New Jersey  
October, 1949

## HOW TO USE THIS BOOK

This is a reference manual. You need not read it through from cover to cover, but I hope you will read the first chapter and then the introduction to garden chemicals, page 7, and the few pages, 22 to 27, on spraying, with particular attention to the conversion table on page 27. Note for future reference that chemicals are listed alphabetically, along with some trade names, and that comments are given on their compatibility and incompatibility with each other and with insecticides.

Chapter 3 on the classification of plant pathogens can be taken or not as desired. It provides a mycological background for students and a brief review for professional workers.

The rest of the book is in two main sections. Chapter 4, starting on page 43, describes specific diseases and gives remedies when known. The diseases are grouped according to their common names into thirty-five types treated in alphabetical order: Anthracnose (p. 44), Bacterial Diseases (p. 58), Black Knot (p. 83), Black Leg (p. 85), Black Mildew (p. 86), Black Spot (p. 88), Blights (p. 95), Blotch Diseases (p. 142), Broomrapes (p. 145), Cankers and Diebacks (p. 145), Club Root (p. 173), Damping-off (p. 174), Dodder (p. 176), Downy Mildews (p. 179), Fruit Spots (p. 185), Leaf Blister and Leaf Curl Diseases (p. 186), Leaf Galls (p. 188), Leaf Scorch (p. 191), Leaf Spots (p. 193), Mistletoe (p. 232), Molds (p. 235), Needle Casts (p. 237), Nematode Diseases (p. 241), Physiogenic Diseases (p. 250), Powdery Mildews (p. 267), Rots (p. 279), Rusts (p. 324), Scab (p. 352), Scurf (p. 361), Smuts (p. 363), Snowmold (p. 367), Sooty Mold (p. 369), Virus Diseases (p. 371), White Rusts (p. 391), Wilts (p. 392). These types are briefly defined on page 407.

Chapter 5, starting on page 405, gives nearly a thousand host plants in alphabetical order, from *Abelia* to *Zinnia*, according to common names except in cases where the Latin name means less confusion. Under the hosts the diseases are sorted out into the thirty-five types and the geographical distribution given. From then on it is a process of checking back into the disease section to get the information applicable to your particular problem. Chapter 4 has a running head of disease types, from Anthracnose to Wilts, but exigencies of manufacture have placed this in the inner margin, not readily seen by riffling the pages, so that the Index may provide a quicker means to the same end. In both disease and host sections the Latin name of the pathogen is given in boldface type and provides the key word, for the individual diseases in each

group are listed in alphabetical order according to the names of their pathogens.

A specific example in the use of this book is given on page 406.

Addresses of state agricultural experiment stations, sources of help for every gardener, are given on pages 669 and 670, followed by a glossary, page 671, and a bibliography where references likely to be of interest to gardeners are separated from those acknowledging source material.

The index includes common and Latin names of host plants, Latin names of pathogens, and common names of the described diseases.

The very best way to use this book is to take it in small doses as needed. Do not let the hundreds of diseases you will never meet worry you too much. And remember that most plants survive, despite their troubles!



## CONTENTS

### Preface

#### CHAPTER

1. INTRODUCTION	1
What is Plant Disease?	2
Plant Diseases Are Not New	3
Plant Pathology in the United States	4
Principles of Disease Control	5
2. GARDEN CHEMICALS AND THEIR APPLICATION	7
3. CLASSIFICATION OF PLANT PATHOGENS	29
4. PLANT DISEASES AND THEIR PATHOGENS	43
Anthracnose	44
Bacterial Diseases	58
Black Knot	83
Black Leg	85
Black Mildew	86
Black Spot	88
Blights	95
Blotch Diseases	142
Broomrapese	145
Cankers and Diebacks	145
Club Root	173
Damping-off	174
Dodder	176
Downy Mildews	179
Fruit Spots	185
Leaf Blister and Leaf Curl Diseases	186
Leaf Galls	188
Leaf Scorch	191
Leaf Spots	193

Mistletoe	232
Molds	235
Needle Casts	237
Nematodes	241
Physiogenic Diseases	250
Powdery Mildews	266
Rots	279
Rusts	324
Scab	352
Scurf	361
Smuts	362
Snowmold	367
Sooty Mold	369
Virus Diseases	371
White Rusts	391
Wilt Diseases	392
<b>5. HOST PLANTS AND THEIR DISEASES</b>	<b>405</b>
List of Agricultural Experiment Stations	669
Glossary	671
Selected Bibliography	681
Index	691

# PLANT DISEASE HANDBOOK

## CHAPTER 1

### INTRODUCTION

The chief hazard any garden plant has to endure is its owner, or gardener. I make this statement unequivocally, after nearly twenty years of visiting home gardens across the country, doctoring gardens in the East, and answering countless inquiries.

Undoubtedly many plants will suffer undue hardship from the publication of this Handbook. It is human nature to read symptoms of an ailment and immediately assume it is your own affliction. Jumping to conclusions is as dangerous to plants as to humans. A sore throat does not necessarily mean diphtheria. Only a trained physician can diagnose probable diphtheria, and a laboratory culture is necessary for positive confirmation.

A spotted or yellowed rose leaf does not necessarily mean rose black spot. More than half the specimens sent to me as black spot are examples of spray injury and most of the rest show reaction to weather conditions, yet gardeners blithely go on increasing the spray dosage, confident that more and stronger chemicals will lick the "disease" and seldom noticing they are nearly killing the patient in the process.

A browning azalea flower does not necessarily mean the dreaded petal blight. This past spring an article of mine on possible azalea troubles appeared in print about the time some azalea bloom in this vicinity was turning brown from a combination of unusual weather conditions. Some gardeners immediately suspected the worst, thought that the southern blight had arrived in the North, and started spraying. The poor plants, suffering from drought and a heat wave, found this very hard to take.

All chemicals used as sprays or dusts are injurious to plants under some conditions, the injury varying with the chemical, the dosage, with the species and even the variety of plant, with the temperature, with the soil moisture, and many other factors. Plants suffering from drought are commonly injured by certain sprays.

So please, please don't jump to conclusions. Don't do anything in a hurry because the plants are getting sick fast and there is no time for a proper diagnosis. Don't rush to the seedstore to buy some chemical just as good as

the one you vaguely remember reading about. Sit down; relax! You have all the time in the world for a proper diagnosis, because, by the time the disease is bad enough for you to notice it, it is probably too late for protective spraying this season anyway.

Browning of an azalea flower means nothing as a diagnostic symptom. It could just as well come from frost or heat or old age as from disease. If the flowers had been limp and collapsed with a *slimy* feel, those would have been good symptoms, but signs of the fungus are needed, too. Thin, slightly curved black bodies (sclerotia) formed at the base of petals would have been distinctive, but most conclusive would have been spores taken from the inside of the petals and examined under the microscope. If they were one-celled but had a little boxlike appendage, then one might have reasonably concluded that *Ovulinia azaleae*, the cause of petal blight, had jumped from Maryland, its present northern limit, to New York.

This is a book of garden diseases, but it is not expected that anyone, amateur or professional, can read a brief description, look at an unfamiliar disease in the garden, and make a very reliable diagnosis. I certainly cannot, and after compiling this tome I am less likely to try than ever before. I have written "water-soaked" or "reddish brown" too many hundreds of times for different diseases to make such symptoms seem very distinctive.

However, if you are a gardener you can narrow the field down considerably by consulting Chapter 5 where host plants are listed in alphabetical order and under each the type of disease—Blight, Canker, Leaf Spot, etc., and then the organisms causing these diseases by their scientific names and the states where they have been reported. Eliminating the types of disease that are obviously different from yours and eliminating diseases that are reported only on the West Coast when you live in New York, you may find only two or three possibilities to look up in Chapter 4 which lists, under the different disease groups, the pathogens in alphabetical order, followed by a discussion of the disease. Don't let all the scientific names worry you. It is the only way to make this a quick and easy reference, for there are very few common names of plant diseases that can be used without confusion. It works just like the telephone book. While thumbing your way down to Smith, John, you do not worry about spelling Smiecinski, C., you pass on the way.

If you are a quasi-professional, like me, with your formal mycology far in the past but trying to keep abreast of a flood of miscellaneous specimens, there is a brief review of the salient, microscopic characters of each genus, together with its classification. This is in small type and can be readily passed over by those interested solely in macroscopic characters.

#### WHAT IS PLANT DISEASE?

There are many definitions of plant disease, the simplest being any deviation from the normal. I still like the one learned in student days, concept of

the late Professor H. H. Whetzel, to whose inspiration I owe this plant doctoring vocation and whose assistant I was privileged to be for ten years. Disease in plants is an injurious physiological process, caused by the *continued* irritation of a primary causal factor, exhibited through abnormal cellular activity and expressed in characteristic pathological conditions called symptoms. The causal factor is a living organism or an environmental condition. Injury differs from disease in being due to the *transient* irritation of a causal factor, as the wound of an insect, sudden freezing or burning, application of a poison.

Plant diseases may be **necrotic**, with dying or death of cells, tissues or organs, **hypoplastic**, resulting in dwarfing or stunting, or **hyperplastic** with an overgrowth of plant tissue, as in crown gall, or club root.

#### PLANT DISEASES ARE NOT NEW

All species of plants, wild and cultivated, are subject to disease. Fossil remains suggest that plant diseases were present on earth before man himself. Certainly man has been punished by them ever since the garden of Eden. "I smote you with blasting and with mildew and hail in all the labors of your hands yet ye turned not to me, saith the Lord" (Haggai 2:17).

Man's attempts at controlling plant disease go back at least to 700 B.C. when the Romans instituted the Robigalia to propitiate the rust gods with prayer and sacrifice. About 470 B.C. Pliny reported that amurca of olives should be sprinkled on plants to prevent attacks of blight, this being our earliest known reference to a fungicide.

In 1660, at Rouen, France, a law was passed calling for eradication of the barberry as a means of fighting wheat rust, two centuries before the true nature of rust was known or how the barberry affected the wheat.

In the latter part of the eighteenth century the English Forsyth discoursed on tree surgery and treatment of wounds and cankers. His seemingly fantastic recommendation of a paste of cow dung to promote healing of tree wounds has modern corroboration in research showing that urea speeds up healing of such wounds.

Much of our progress in dealing with plant disease has followed spectacular catastrophes. Modern plant pathology had its start with the blight which swept the potato fields of Europe in 1844 and 1845, resulting in the Irish famine. This lesson in the importance of plant disease to the economic welfare of mankind marked the beginning of public support for investigations on the cause of disease. Two men, both German, laid the firm foundations of our present knowledge. Mycologist Anton de Bary, 1867 to 1888, first proved beyond doubt that fungi found associated with plant diseases were pathogenic, while Julius Kuhn, farmer with a doctor's degree in science, first showed the relation between science and practice in the problems of plant disease control. His textbook on *Diseases of Cultivated Plants*, published in 1858, is still useful.



The accidental discovery of bordeaux mixture in France in 1882 marks the beginning of protective spraying for disease control, although sulfur dust had been recommended as an eradicant for powdery mildew back in 1824.

#### PLANT PATHOLOGY IN THE UNITED STATES

Organized plant pathology in America started in 1885 with a section of Mycology in the U.S. Department of Agriculture. In 1904 the start of the great epiphytotic of chestnut blight which was to wipe out our native trees stimulated more public interest and support for plant pathology. In 1907 the first University Chair of Plant Pathology was established at Cornell University.

The United States Quarantine Act of 1912 officially recognized the possibility of introducing pests and diseases on imported plants, after low-priced nursery seedlings from Europe had brought in the white pine blister rust, and this was our first attempt at control by exclusion.

In 1917, during World War I, the Plant Disease Survey was organized as an office of the Bureau of Plant Industry "to collect information on plant diseases in the United States, covering such topics as prevalence, geographical distribution, severity, etc. and to make this information immediately available to all persons interested, especially those concerned with disease control." This information comes to the Survey from volunteer collaborators all over the country and is distributed in a mimeographed bulletin, *The Plant Disease Reporter*.

During World War II, the Plant Disease Survey was in charge of the Emergency Plant Disease Prevention Project to "protect the country's food, feed, fiber and oil supplies by ensuring immediate detection of enemy attempts at crop destruction through the use of plant diseases and providing production specialists and extension workers with prompt and accurate information regarding outbreaks of plant diseases whether introduced inadvertently or by design while still in incipient stages." The role of the G-men of plant disease and the methods they used is not yet fully told, but as a by-product of these wartime surveys we accumulated a great deal of evidence on the presence and prevalence of new and established diseases across the country and this included home gardens as well as farms. Much of the material in this Handbook can be regarded as another by-product of these surveys.

In 1946, a century after *Phytophthora infestans* had made history with the potato blight, a strain of the same fungus started an unprecedented epiphytotic of tomato blight, as devastating in home gardens as in canning crops. And this disaster led directly to the latest service of the Plant Disease Survey, A Crop Plant Disease Forecasting Project authorized under the Research and Marketing Act. Clearing through key pathologists in each state, information flows to and from the Survey in time to warn dealers to lay in their stocks of chemicals and growers to be ready to spray when disease is imminent. Late blight of potato and tomato, tobacco blue mold, and cucurbit downy

mildew are the three diseases for which forecasts were attempted the first year, but doubtless the service will be expanded as the need develops.

### PRINCIPLES OF CONTROL

Control of a plant disease means reduction in the amount of damage caused. Perfect control is rare, but there is profitable control when the increased yield more than covers the cost of chemicals and labor, or when the ornamentals in our gardens stay beautiful instead of becoming unkempt horrors.

The four fundamental principles of control are Exclusion, Eradication, Protection, and Immunization.

1. **EXCLUSION** means preventing the entrance and establishment of pathogens in uninfested gardens, states, or countries. For home gardeners it means using certified seed or plants, sorting bulbs before planting, discarding any that are doubtful, possibly treating seeds or tubers or corms before they are put in the garden, and, most especially, refusing obviously diseased specimens from nurseryman or dealer. For states and countries, exclusion means quarantines, prohibition by law. Sometimes restricted entry of nursery stock is allowed, the plants to be grown under isolation and inspected for one or two years before distribution is permitted.

2. **ERADICATION** means the elimination of a pathogen once it has become established on a plant or in a garden. It can be accomplished by *removal* of diseased specimens, or parts, as in roguing to control virus diseases, or cutting off cankered tree limbs; by *cultivating* to keep down weed hosts and deep ploughing or spading to bury diseased plant debris; by *rotation* of susceptible with nonsusceptible crops, trying to starve out the pathogen; and *disinfection*, usually by chemicals, sometimes by heat treatment. Spraying or dusting foliage with sulfur after mildew mycelium is present is eradication, and so is treating the soil with chloropicrin to kill nematodes and fungi.

3. **PROTECTION** is the interposition of some protective barrier between the susceptible part of the susceptible plant or host and the pathogen. In most instances this is a protective spray or dust applied to the plant in advance of the arrival of the fungus spore; sometimes it means killing insects or other inoculating agents, sometimes the erection of a windbreak or other mechanical barrier.

Chapter 2 gives an alphabetical list of chemicals used in present-day protective spraying and dusting, along with eradicant chemicals, and includes notes on compatibility and possibilities of injury. It is here that home gardeners, sometimes commercial growers, can do their plants irreparable harm instead of the good they intend. Spraying is never to be undertaken lightly, or thoughtlessly. Stop and think! Read all of the fine print on the labels; be sure of your dosage, and the safety of that particular chemical on the plant you want to protect.

4. **IMMUNIZATION** is control by the development of resistant varieties or by inoculating the plant with something which will inactivate the pathogen.

The latter is a very recent phase of plant disease control. We call it chemotherapy, and promising results have been obtained with Dutch elm disease, bleeding canker of maples, and one or two others. Resistant varieties are as old as time. Nature has always eliminated the unfit, but since about 1890 man has been speeding up the process by deliberate breeding, selecting, and propagating plants resistant to the more important diseases. It was estimated in 1937 that disease-resistant varieties of 17 farm crops added upwards of 70 million dollars a year to farm incomes. Some crops could not be grown at all if it were not for resistant varieties.

Resistant ornamental plants have lagged behind food plants but we do have wilt-resistant asters, rust-resistant snapdragons, and we hope that elms that can withstand Dutch elm disease and wilt-resistant mimosas are on the way. Here is the ideal way for home gardeners to control their plant diseases—in the winter when the seed order and the nursery list is made out—so easy, and so safe!

## CHAPTER 2

# GARDEN CHEMICALS AND THEIR APPLICATION

### FUNGICIDES, BACTERICIDES, NEMATOCIDES

A **fungicide** is a toxicant or poison for fungi, a chemical or physical agent that kills or inhibits the development of fungus spores or mycelium. It may be an **eradicator**, applied to a plant, plant part, or the environment to destroy fungi *established* within a given area or plant, or it may be a **protectant**, applied to protect a plant or plant part from infection by killing or inhibiting the development of fungus spores or mycelium that *may arrive* at the infection court. The term fungicides as generally used includes bactericides, toxicants for bacteria.

A **disinfectant** is an agent that frees a plant or plant part from infection by destroying the pathogen *established within it*. A **disinfestant** kills or inactivates organisms present *on the surface* of the plant or plant part or in the immediate environment. Chemicals for seed treatment can be either eradicants or protectants but most of them are disinfestants in that they kill organisms on the surface of the seed rather than those within. In common usage, however, they are called disinfectants.

A **nematocide** is, of course, a chemical that kills nematodes in the soil or in the plant. Most nematocides are **fumigants**, chemical toxicants applied in volatile form.

Not so long ago the chemicals on the garden medicine shelf consisted of copper and sulfur for protectants, lime sulfur as an eradicator, mercuric chloride as a disinfectant, and formalin and carbon bisulfide as fumigants. You sometimes got plant injury; you did not always get the best possible control but at least you did not have to be an organic chemist. Now we have added "fixed" coppers, organic sulfurs or dithiocarbamates, phenyl mercury derivatives, chlorinated quinones and naphthoquinones, metallic quinolinolates, quaternary compounds, glyoxalidines, nitrated phenols or dinitro derivatives, compounds of chromium, cadmium, silver, and zinc as fungicides; and the fumigants chloropicrin, dichloropropylene and dichloropropane, methyl bromide, ethylene dibromide, and ethylene dichloride as nematocides.

Many of these were developed to meet an emergency—the sudden need for fungicides to combat tropical fungi deteriorating fabrics and equipment during World War II, but the search for new fungicides goes on, with hundreds of synthetic organic compounds being screened each year. This screening is