# Westcott's Plant Disease Handbook

R. Kenneth Horst

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Eighth Edition

With 87 Figures and 2 Tables

Springer Reference

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*This 8th Edition of the Plant Disease handbook is dedicated to the mentoring experiences I have had the pleasure of experiencing starting with Pleasant View Grade School, North Lawrence, OH, to Massillon Washington High School, Massillon, OH, to Ohio University, Athens, OH, to The Ohio State University, Columbus, OH, to Yoder Bros., Inc., Barberton, OH, to Cornell University, Ithaca, NY (Professor, Department of Plant Pathology and Plant-Microbe Biology). Although I felt in those early years that I was doing all the learning, I soon found that mentoring was a two-way phenomenon. Not only was I mentoring my students at Cornell University, but I found I was learning from them as well.*

*I was stimulated to reflect on this by my two youngest grandchildren, Madeline Turner and Trevor Horst to whom I dedicate this 8th Edition as well as the students who taught me while I was teaching them. Madeline initiated this process when I asked her what she was learning in kindergarten. She listed all that she was learning. I indicated she was really getting smart and that maybe Grampy should go to kindergarten so that he could get smart. She said "No Grampy you can't" and I asked her "why not" and she said "Because you're no kid anymore". What a great answer and also very profound since she was really telling me I needed to continue moving beyond being a kid in my learning process.*

*Students (Masters, Doctoral and Post-Doctoral Students) I have mentored and from whom I have also learned much.*

*Jamil Abu-Sadah*
*Richard Biamonte*
*Lester Burgess*
*Eugene Oscar Erickson*
*Donna Gardiner-Matteoni*
*Mary Handley*
*Jeffrey R. Houge*
*Hussein Ali Ahmed Hussein*
*Catherine M. Klein*
*Selin Kryzcynski*
*Randolph Edward McCoy*
*Robert J. McGovern*
*Elzbieta Paduch-Cichal*
*Cristi Lynn Palmer*
*Hugh Allen Poole*
*Leah LeEarle Porter*
*Ramona Ann Reiser*
*Charles Peter Romaine*
*Nancy Jane Schenk*
*Margosheta Schollenberger*
*Gail Lynn Schumann*
*Ann Finer Silverglate*
*Robert W. Stack*
*Marek Szyndel*
*Arnold T. Tschanz*
*Sek-Man Wong*

# Preface to the Eighth Edition

It was a compliment to me to be asked to prepare the fourth edition of *Wescott's Plant Disease Handbook*, and the decision to accept the responsibility for the fourth edition, the fifth edition, the sixth edition, the seventh edition, and now the eighth edition was not taken lightly. The task has been a formidable one. I have always had great respect professionally for Dr. Cynthia Westcott. That respect has grown considerably with the completion of the five editions. I now fully realize the tremendous amount of effort expended by Dr. Westcott in developing the *Handbook*. A book such as this is never finished, since one is never sure that everything has been included that should be. In the 4 years since the seventh edition there were more than 600 new reports of diseases on plants. I would quote and endorse the words of Dr. Westcott in her preface to the first edition: "It is easy enough to start a book on plant disease. It is impossible to finish it . . ." Dr. Cynthia Westcott passed away March 22, 1983.

This revision of the *Handbook* retains the same general format contained in the previous editions. The chemicals and pesticides regulations have been updated; major taxonomic changes have been made in the bacteria, fungi, nematodes and viruses; the changing picture in diseases caused by viruses and/or virus-like agents have been described. New host plants have been added, and many recently reported diseases as well as previously known diseases listed now on new hosts have been included in the Handbook. In addition photographs have been retained from the seventh edition as well as the color photograph section. For the photography work I am grateful for the help and expertise of Kent E. Loeffler. I also had access to the Cornell Plant Pathology Herbarium, which contains a wealth of photographic work on plant diseases that has been supplied by numerous scientists over many years.

This book should be useful to gardeners, master gardeners, botanical gardens, landscape architects, florists, nurserymen, seed and fungicide dealers, pesticide applicators, arborists, cooperative extension agents and specialists, plant pathologists, diagnostic laboratories and consultants. The book should also be a useful reference book for plant pathology classrooms and in some cases used as a textbook.

March 2013 R. Kenneth Horst

# Acknowledgments

I am indebted to many people for advice and suggestions for the 8th Edition. The reviewers acquired by Kluwer Academic Publisher to review the 5th Edition and to advise on significance of a 6th Edition provided many helpful suggestions which were used in the 7th and 8th Editions. Moreover, a few individuals who were particularly helpful in my tasks of updating and putting together the revision for the 8th Edition into an appropriate format were J. Esnard, K. Hodge, S. J. Ingalls, K. Loeffler, C. Palmer, K. Snover, R. E. Stall, B. Szyndel and M. S. Szyndel. Finally, I recognize and appreciate the professional and efficient job of typing the manuscript by Margaret Haus and her dedicated efforts in aiding me in proofreading, which was a major task with the increasing size of the book and the changing scientific names of the pathogenic organisms.

# How to Use This Book

This is a reference manual. You will certainly not read it through from cover to cover, but I hope you will read the first and last section of ▶ Part I on garden chemicals. The chemicals themselves are listed in alphabetical order, by common names where possible, by trade names where these are used in lieu of approved common names. A few materials still in the experimental stage but very promising are included. A few uses are suggested, but many more, with correct dosages, will be found on the labels or in recent publications. ▶ Part II, on the classification of plant pathogens, can be taken or not as desired. It provides a mycological, bacteriological, nematological and virological background for students and a review for professional workers. The bibliography gives some of the taxonomic references consulted in preparing this very condensed treatment.

The rest of the book is in two main sections. ▶ Part III describes specific diseases and gives remedies when known. The diseases are grouped according to their common names into forty types treated in alphabetical order. ▶ Part IV gives over 1300 host plants in alphabetical order, from Abelia to Zoysia, according to common names except where the Latin name may mean less confusion. Under the hosts the diseases are sorted out according to types, given in small capitals, and you can quickly thumb back to the corresponding section, Anthracnose, Blight, Wilt, etc., in ▶ Part III by means of the running head at the top of each page.

The book works like a dictionary. In both the disease and host section the Latin name of the pathogen causing the disease is given in **boldface** type. The individual diseases in the host section are listed in alphabetical order according to the common name of the diseases.

You may be able to find the information you are seeking directly from the index, which includes common and Latin names of hosts plants, Latin names of pathogens and common names of the diseases described in ▶ Part III. More than 4000 diseases are included in that chapter and some additional pathogens are listed under Host Plants without a corresponding description of disease.

Website addresses of state universities and agricultural experiment stations, which are sources of help for every gardener, are given following ▶ Part IV. 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

# Introduction

The chief hazard any garden plant has to endure is its owner or gardener. Moreover, 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 for positive identification a laboratory culture is necessary.

A spotted or yellowed rose leaf does not necessarily mean rose black spot. Mite injury, spray injury, or reaction to weather conditions may also cause spotted or yellow rose leaves; yet gardeners blithely continue increasing the spray dosage, confident that more and stronger chemicals will control the "disease" and seldom notice they are nearly killing the patient in the process. A browning azalea flower does not necessarily mean the dreaded petal blight. Some years ago a Westcott article on possible azalea troubles appeared in print about the time azalea blooms in a Northern region were turning brown from a combination of unusual weather conditions. Some gardeners immediately assumed 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, suffered additional injury from the additional stress of sprays. All chemicals used as sprays or dusts are injurious to plants under some conditions, the injury varying with the chemical and the dosage, with the species and even the variety of plant, with temperature, soil moisture, and many other factors. Plants suffering from drought are commonly injured by sprays.

So 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 seed store to buy some chemical you vaguely remember reading about. Relax! You have all the time in the world for proper identification, since, by the time the disease is serious enough for you to notice, 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, heat, or old age as from a pathogen. If the flowers are limp and collapsed with a *slimy* feel, these are good symptoms, but signs of the fungus are needed as well. Thin, slightly curved black bodies (sclerotia) formed at the base of petals are distinctive, but even more conclusive are spores taken from the inside of the petals and examined under

a microscope. If these are one-celled, with a little box-like appendage, then you may reasonably conclude that you have the true azalea petal blight.

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 ▶ Part IV, 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 ▶ Part III, which lists, under the different disease groups, the pathogens in alphabetical order, followed by a discussion of each disease. In situations where pathogen names have been changed due to critical investigations of spore formation and development, the original name is listed in alphabetical order followed by "see new name". Under the new name in parenthesis "formerly old name" is indicated.

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., which you pass on the way.

If you are a quasi-professional, with little or no formal mycology but trying to keep abreast of a flood of miscellaneous specimens, there is a brief review for you of the salient microscopic characteristics of each genus, together with its classification. This is in small type and may be readily passed over by those interested solely in macroscopic characteristics.

## What is Plant Disease?

There are many definitions of plant disease, the simplest being any deviation from the normal. The concept of the late professor H. H. Whetzel, a great teacher of plant pathology who influenced many students including Dr. Cynthia Westcott, is valid and appropriate even today. "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 may be 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, although Homer, 1000 B.C., wrote of "pest-averting sulfur."

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 anyone knew the true nature of rust or how barberry affected wheat.

In the latter part of the eighteenth century the Englishman 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 that 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 into 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 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, but the use of drugs goes back to 1824, when sulfur was recommended as an eradicant for powdery mildew. The development of synthetic organic fungicides was sparked by World War II, partly as a result of a search for chemicals to mildew-proof fabrics used by the armed forces. Antibiotics for plant disease control followed their use in medical practice, with a great deal of research in this field since 1949.

Since the establishment of the Environmental Protection Agency in 1972 there has been increased concern on the use of toxic chemicals for controlling plant disease. Moreover, this concern has generated renewed interest in integrated pest management (IPM) and biological control strategies in the 1980's. IPM utilizes all available pertinent information regarding the crop or plant, its pathogens, the environmental conditions expected to prevail,

locality, availability of materials, and costs in developing the control program. Biological control is the total or partial destruction of pathogen populations by other organisms. This phenomenon occurs routinely in nature. There are several diseases in which the pathogen cannot develop because the soil, called suppressive soils, contain microorganisms antagonistic to the pathogen, or because the plant that is attacked has been naturally inoculated before or after the pathogen attack, with antagonistic microorganisms. Even higher plants may reduce the amount of pathogen inoculum by trapping available pathogens (trap plants) or by releasing substances toxic to the pathogen into the soil. Although biological antagonisms are subject to numerous ecological limitations it can be expected to become an important part of control measures employed against many more diseases in future years.

## Plant Pathology in the United States

Organized plant pathology in the United States 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 Department 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. 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." During World War II the Plant Disease Survey was in charge of the emergency 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."As a by-product of these wartime surveys we accumulated a good deal of evidence on the prevalence of new and established diseases across the country, in home gardens as well as on farms.

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. This disaster led to the forecasting service warning dealers and growers when certain diseases are imminent.

The Plant Disease Survey has now become the Epidemiology Investigations Section of the Agricultural Research Service of the U.S. Department of Agriculture. The Agricultural Research Service became a part of the Science and Education Administration in 1978. It issues a monthly bulletin, *The Plant*

*Disease Reporter*, based on reports from qualified volunteer collaborators all over the country. The American Phytopathological Society assumed the responsibility for publishing this journal in 1980 and the journal was renamed *Plant Disease*. Much of the material in this handbook is taken from these reports.

## Principles of Control

Control of a plant disease means reduction in the amount of damage caused. Our present annual toll from disease is nearly four billion dollars. Perfect control is rare, but profitable control, when the increased yield more than covers the cost of chemicals and labor, is quite possible. Commercial growers now average a return of four dollars for each dollar so invested. Keeping home plantings ornamental yields a large return in satisfaction and increased property value.

The five fundamental principles of control are exclusion, eradication, protection, resistance, and therapy.

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 planted, 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 in 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 to starve out the pathogen; and by *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 suspect 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 it means the erection of a windbreak or other mechanical barrier.

   ▶ Part I 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 label; be sure of your dosage and the safety of that particular chemical on the plant you want to protect, to say nothing of precautions necessary for your own safety.

4. *Resistance* is control by the development of resistant varieties. 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 deliberately breeding, selecting, and propagating plants resistant to the more important diseases. Resistant ornamental plants have lagged behind food plants, but we do have wilt-resistant asters, rust-resistant snapdragons, wilt-resistant mimosas. 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!
5. *Therapy* is control by inoculating or treating the plant with something that will inactivate the pathogen. Chemotherapy is the use of chemicals to inactivate the pathogen, whereas heat is sometimes used to inactivate or inhibit virus development in infected plant tissues so that newly developing tissue may be obtained which is free of the pathogen. The use of this procedure is discussed in ▶ Part II.