Bacterial and Fungal Diseases of Plants in the Tropics

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Foreword

ONE OF THE continuing problems facing agricultural development in tropical and semitropical areas, which are frequently the underdeveloped areas of the world, is the identification and treatment of bacterial and fungal diseases of plants. The need for a textbook which clearly describes the symptoms and the causal agents of specific plant diseases has long been evident, for use abroad as well as in United States universities in training students from tropical and semitropical areas.

It has been pointed out that training in plant pathology in the United States focuses primarily on basic principles of the discipline. This, perhaps, is as it should be. On the other hand those who will be working in tropical countries have a need for more descriptive and applied phases of the subject.

Out of a background of forty-two years of successful teaching and research, covering work in both basic and applied phases of plant pathology, Dr. George F. Weber sets his hand to meeting the needs of the student and the working plant pathologist in the tropical and semitropical areas of the world. He has carefully selected the more important diseases of over one-hundred economic plants and described their symptoms. In addition, symptoms and parasites are illustrated with numerous photographs. The less important organisms frequently associated with cultivated plant diseases are also listed, although not treated in detail.

Confronted with an immediate disease problem, one might wish for more detail on control methods, but Dr. Weber wisely treats of such methods sparingly, knowing full well of ever changing recommendations, the diversity of conditions under which plants are grown, and the continuous development of resistant plants through selection and hybridization.

It has been my privilege to have known Dr. Weber since 1934. He has been an exceedingly productive investigator and teacher in dealing with basic principles as well as coming to grips with the applied and practical aspects of plant disease identification and control. He has constantly attempted to make his teaching meaningful and realistic. Certainly this volume reflects that approach in meeting the needs of those who are serving and will serve in tropical and semitropical areas of the world.

J. Wayne Reitz
President Emeritus
University of Florida

Preface

NO CLASSIFICATION is perfect: nature recognizes no very marked divisions. As Professor Massee, of Kew, used to say 'why make a fence! Some rooster is sure to get on top of it with his head on one side and his tail on the other!' And often the higher realms of perfection are of little practical use. It is vastly more important to help twenty students to a better knowledge of a group of plants than to tickle the fancy and win the praise of one who no longer needs help. Anyone leaving the beaten track is subject to criticism, when he should get only sympathy." William A. Murrill. 1917. *American Journal of Botany* 4(6):315.

The purpose of this volume is to bring to teachers, students, agricultural agents, extension advisers, growers, crop production managers, farmers, and landowners a guide to the identification of plant diseases through the use of diagnostic symptoms and the characteristics of the causal parasite.

The data have been accumulated during the past half century by the writer as a student, research specialist, teacher, student counselor in the Agency for International Development, consultant, editor, and the author of more than a hundred publications. Additional data have been supplied by scores of students from tropical countries who have attended the College of Agriculture, University of Florida, and its several branch stations in order to pursue advanced studies in the area of plant pathology. Discussions concerning their local plant disease problems have been of considerable importance in relation to the selections included here.

The book is arranged alphabetically by common host name. For each host there is a list of specific diseases and causal agents, followed by a description of symptoms and the essential characteristics and etiology of the parasite. The diseases listed are arranged by the phytogenic relations of the parasites. Each section is concluded with a list of references and a list of additional fungi that may be infrequently associated with the host, but nevertheless cause severe damage.

Rhizoctonia occurs in the literature frequently. During the hundred years since it was first described, the name of the fungus has been changed to *Corticium*. Through recent studies, this genus has been subdivided into several new genera including: *Botryobasidium*, containing *B. microsclerotia*, *B. rolfsii*, and *B. salmonicolor*; *Ceratobasidium* with a single species, *C. stevensii*; and *Thanatephorus* with two species, *T. cucumeris* and *T. sasakii*. *Sclerotium*, also an imperfect fungus with worldwide distribution, has been studied, and the spore forms discovered place it in *Macrophomina phaseolina*, with *Sclerotium bataticola* as a synonym, *Stromatinia cepivorum* with *Sclerotium cepivorum* as a synonym, and *Leptosphaeria salvinii* with *Sclerotium oryzae* as a synonym. In addition to *Rhizoctonia*, *Corticium*, and *Sclerotium*, the abovementioned binomials will be used in the text.

The nomenclature of host plants and authorities used follows very closely that presented by Dr. L. H. Bailey in *Manual of Cultivated Plants* and Dr. J. K. Small in *Manual of the Southeastern Flora.* Other references dealing with tropical plants have been consulted, particularly Dr. H. F. MacMillan's *Tropical Planting and Gardening.*

The binomials of parasitic organisms have been obtained from the current literature in general and in most instances coincide with the contents of the *Index of Plant Diseases in the United States*, United States Department of Agriculture Handbook Number 165. Authorities for binomials of cryptogams have been derived from this handbook and from L. Roger's list in *Encyclopedie Mycologique* 19:2923–32. There has not always been complete agreement among literature references, and it is hoped that the choices have not been unreasonable and that should mistakes occur they will be forgiven. They are entirely the responsibility of the writer.

This book is constructed primarily as a source of authoritative, accurate, condensed, diagnostic information acquired from and supported by existing cited literature and the author's researches and observations. Excellent monographs and books dealing exhaustively with diseases of specific hosts or groups of hosts are plentiful and usually well distributed. A bibliography of the contributions in subjects related to plant diseases is supplied and is supplemented by a list of useful reference journals. The illustrations, mostly originals by the author, are credited otherwise.

The initial idea for this work and the encouragement necessary for its continuation came from the author's association with foreign students, and the project has become increasingly necessary and real as a contribution to them.

Acknowledgments

THE LIST OF COLLEAGUES and friends to whom my indebtedness is extended is very long indeed. I cannot sufficiently thank them for their help which has so greatly enhanced whatever value this volume may have in lightening the burden of those responsible for leading and guiding those who are uninformed but eager to learn.

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The contributions of the following people, through correspondence, by individual contact in the United States or abroad, and as students attending the university while undergoing special training or studying for advanced degrees, have been freely given and have been carefully considered in relation to the selection of many of the hosts and diseases presented herein. They have been important participants, probably unknowingly, in the accumulation of the contents of this volume and it is hoped that they may experience some pleasure in their endeavors. To them I am most cordially extending thanks and appreciation in acknowledging my obligation. Brazil: J. S. Aroeira, A. C. Batista, E. France, F. Galli, D. C. Giocometti, Ear Kimmal, L. G. Lordehlo. Cambodia: Sam E. Jalcofy. Colombia: José V. Arboleda. Costa Rica: C. E. Fernandez, Ed. Jimenez, Manuel Jimenez. Cuba: Hera Acuna, Julio Capo-Mass. Ecuador: Mario Jalil. Ethiopia: Amare Aetakum. El Salvador: Gilberto R. Aguila, Oscar Ancalmo, Carlos Buryos, Aristides Escobar, Karl Flores, José E. Funes, Bernardo Patino, Tomas Villanova. Greece: P. I. Constantinou, C. Catseurbos. Guatemala: Mario Fernandez. Honduras: Emilio Coto, Miguel A. Elvir, Jorge Maradiaga, Zuniga Ridoniel, Bernardo Roehrs. India: Sheth Anilkumat, R. Radhikrishna, G. N. Safaua, P. P. Ninjappa. Indonesia: Faisal Aman, Ishak Mohamad, Ida M. Oka. Iran: Mohammod Akhauzodegan, Hojjute S. Moosa, Aziz Shiralipour. Malayasia: Abraham Yusof. Mexico: Dagoberto Aguilar, Badillo Pacheco. Nicaragua: Vernon D. Bent, José C. Camales. Pakistan: Abdul G. Kausar. Panama: Alberto Broce. Peru: Paul H. Figueroa, Rafael Franciosi. Philippines: Juan T. Carlos, Tricita Hidalgo, Miouisio Minora, Faustino T. Orillo. Puerto Rico: Marciso Almeyda. Taiwan: Sing Ching Chen, Y. J. Chin, Ching-Chen Chow, Chalo Tsing, Chin-Chyu Tu. Thailand: Saksiri Kirtpredi, Sasipalin Pisit, Sowart Ratanaivorabhan, Sompark Siddhipongse, Sataeoth Pramaun, Phongsayam Sausar. Turkey: Ismail Baykal. Uruguay: Oscar Abaracon. Venezuela: R. E. Pontis. Viet Nam: Ha Thu Nguyen, Van Hank Nguyen.

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Introduction

SINCE THE BEGINNING of civilization the tiller of the soil has been robbed of some of the fruits of his labours by plant diseases." C. H. Gadd (Ceylon).

The low elevations in the tropics are generally considered to be wet and warm, conditions conducive to luxuriant plant growth. The highlands provide ecological conditions in relation to altitude that correspond to latitude in other crop producing areas of the world. These environmental factors are favorable to the development of plant diseases. To improve and increase the food derived from primitive agriculture, a knowledge of plant diseases and some idea of how to combat them must be supplied.

The production of food and fiber is most essential for survival. Loss of these products attributed to pathogenic organisms occurs wherever plants are grown. Ecological factors in relation to plant development are highly variable and must be considered when selecting types and quantity of plants to grow. As these conditions vary around the world, crop plants likewise vary. Causes of some losses are associated with fungi. Therefore, it is most desirable to prevent such disease-producing plants from destroying those under cultivation. This, then, becomes a problem of plant disease control. Some suggestions are implied here, although specific formulas and directions are intentionally avoided. Effective methods and means for crop plant preservation in one area may not be most efficient in another.

The application of disease control in the early stages of experimentation usually centers around the recognition of the symptoms and their association with various phases of the life cycle of the organisms present. This information is pertinent to proper diagnosis, supported by Koch's Postulates. When these facts are known there is established a factual basis for methods of control. If this information is not available, control may not be successful. On this premise, emphasis is directed toward an accurate understanding of plant disease symptoms and detailed knowledge of the life cycles, etiology, and morphology of fungi. The most urgent and pressing problems which the inhabitants of many tropical lands must face is how to close the gap between production and consumption of food. Investigations on the scale of scientific research into the cause of plant diseases are still largely in the hands of very few. With political freedom and its associated responsibilities, there develops a change from being dependent on outsiders to show the way to carrying the burden themselves. Increased food production requires more cultivated lands, fertile and supplied with economic plants and readily available water. These basic requirements must of necessity be correlated with a knowledge of cultural methods and the use and storage of yields. Even when the prospects appear to be very good, plant diseases have been known to be destructive and cause famine. Information from throughout the world must be accumulated, compiled, and supplied to struggling populations so that they may help themselves to a better existence.

The environment surrounding growing plants is most important since the plant is stationary and must survive or perish under existing or developing conditions supplied naturally or artificially. Meteorological factors are mostly included under the headings of temperature, light, air, humidity, topography, and mechanical forces such as wind damage, hail, and flooding. These are highly variable and as a group are exceedingly influential in plant distribution and survival and are often directly related to the prevalence of disease. Other contributing influences are associated with the soil as the medium in which the plant grows. Again, there is a certain overlapping of temperature and moisture, but added to these are the importance of soil texture, reaction, compactness, toxicity, deficiencies, slope, origin, and age. The biological aspects naturally introduce most of the diseases of plants such as those caused by animals, nematodes, insects, parasitic plants, viruses, bacteria, and fungi. It is to these that more detail is given in order to aid in their prevention, control, and elimination.

In a large number of specific areas in certain states and countries, laws, rules, and regulations are in force for the specific purpose of excluding by the existence of a quarantine the transportation of herbage of any kind into designated places. These become operational and are executed through inspection by competent inspectors with the authority of refusal of movement or confiscation and destruction. The first operation of control is *exclusion* by any means possible of any disease that may threaten the productive life of a plant and its fruit. This is brought about by the formation of a barrier that is sufficient to prevent the ingress of outsiders. Physical structures such as covered houses, flowing water, open ditches, and windbreaks have been used. The entire universal application of quarantine and regulations between states, countries, and continents is promulgated and enforced as a means of plant disease control.

The process of freeing an area of contaminated and diseased plants and reducing the population of soil inhabitors suggests the possibilities of roguing and destruction of plants or plant parts that might spread diseases. This operation should be followed by rotation and fallow as a means of reducing susceptible hosts or alternate hosts of specific parasites. There are certain soil treatments that should be used in reducing populations of detrimental organisms. Applications of heat at specific temperatures and gas at lethal concentrations associated with antibiotics are usually successful in at least commercial control.

Control of disease-producing, soil-inhabiting parasites associated with soil treatments is the protection given to seeds to rid them of contaminants by aging them sufficiently so that many associated organisms fail to survive. Seed are protected by applying certain fungicides and coating them completely prior to admitting them to the growing medium. There are ways of protecting plants to a certain extent by raising barriers around them, producing trellises, raising them above soil surface, alternating with a crop-free season, supplying a trap crop, trenching to prevent root intermingling, high budding of perennials, and off-season or out-of-season planting of a susceptible crop, resulting in disease escape. There are many examples illustrating the successful use and application of each of these methods.

If, however, none of the precautionary applications is sufficient to prevent invasion of the protected area, then it becomes necessary to use *eradication* for plant disease control. This implies the destruction of parasites and the diseases they cause. Certain forms of seed and soil treatments and fumigation are generally applied. Often plant parts are removed and frequently whole plants extirpated. There are many control formulae applied to entire plants and to their products in a wide range of operations. The success obtained is usually correlated with strict adherence to methods of operation. When operations associated with the parasites have not been sufficient to prevent crop losses it becomes apparent that *protection* of plants in their healthy condition is necessary.

Fungicides of various compositions, applied as dust or as sprays, are in most instances intended to function as protectants. They form a coating or layer of material that is toxic to the spores of fungi, and, if properly formulated and carefully applied at the proper time, are nondetrimental to the tenderest plant parts. To be most effective applications to growing plants must be made at 7 to 10 day intervals for continuous complete coverage. Protection is gained by coating seed with a fungicide that is retained through the germination period. Spreaders and stickers are useful on many occasions to assure complete and prolonged benefits.

Frequently, eradicant fungicides are profitably used in proper disinfection and sterilization of soil and growth media. They are used effectively as sprays in more concentrated form as applicants to plants that are deciduous and dormant.

Chemotherapy is also a promising treatment for plants, both as a protectant and eradicant. It offers much for future consideration but is not extensively applied at the present time. Systemic fungicides also require increased attention.

Most of these operations are usually considered temporary and effective for only a short time during growing season and must of necessity be repeated. This form of control is adequately demonstrated by the application of fungicidal sprays and dusts to fields, groves, and orchards. There are certain chemical solutions used in disinfecting washes sufficient to prevent invasion through natural openings or through mechanical injuries. Certain plants are protected from disease organisms, because of natural spaces through which the parasite does not survive. However, there is always the failure of commercial control, and then it becomes necessary to further manipulate the cultivated plant.

The lengthy duration of corrective methods is associated with resistance of the plant to pathogens. The discovery of resistance associated with natural chimeras and sports as plant variations in nature have been successful. Plant cultivators must be continually alert in order to recognize the external manifestations associated with resistance. They are seldom detected unless one is looking for such occurrences. Actually, however, the plant breeder, knowledgable in genetics and the manipulation of chromosomes, makes possible new segregates that may contain the desirable characteristics and be resistant. They perfect the selection of hybrids that survive successive inoculations by pathogens that cause disease. Resistance is not a guarantee of permanent disease control; it is, however, a means of producing profitable crop plants and may lead to the discovery of immunity at any time as a final successful way of growing plants in the presence of virile parasites. This is possible when *resistance* to disease is recognized in plants. There has been a great deal of searching for plants that develop in the presence of virulent disease-producing parasites. The variation in plants which continues to take place in nature offers the keen observer an opportunity to utilize their inherited tendencies.

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Moko wilt, *Pseudomonas solanacearum* E. F. Sm.

Symptoms

Early symptoms are rusty brown linear streaks along the veins on some or all of the leaves. The disease spreads laterally from vein to vein. Severely diseased leaves show parallel streaks from midrib to blade margins. Necrotic streaking is accompanied by considerable yellowing and is followed by browning, drying, and death of the leaf. The leaf petiole may collapse at the base or farther up the midrib and hang down. Often the central leaves show the streaks, or they may wilt abruptly. The entire plant may wilt with no streak apparent. Cross sections of the pseudostem and rhizome reveal a brown to almost black discoloration of the vascular tissue. Sections of the rhizome show discolored spots where the infected vascular tissue connects with the young suckers, which then become inoculated.

Etiology

The organism is a short, gram-negative rod, single or in pairs, motile by a single polar flagellum, and measures $1\text{–}5 \times 0.5\ \mu$. Culture colonies are opalescent, dirty white becoming brown, small, irregular, smooth, and shiny. Optimum temperature, 36–37C.

References

4, 7.

Dry sheath rot, *Marasmius semiustus* Berk. & Curt.

Symptoms

The disease spreads in the pseudostem but usually is found first on the roots and corms. The leaf sheaths become watery and turn brown. As the fungus develops, it grows into the next interior leaf sheath, causing the invaded sheaths to stick together because of an abundance of white mycelium that continues to penetrate deeper. As the outer sheath becomes more completely invaded, it turns brown and dies but remains in place. Under favorable moisture and temperature conditions, mushroomlike fruiting bodies appear on the dead tissue.

Etiology

The mycelium penetrates inward and usually extends to the innermost part of the pseudostem; sometimes the flowering stalk is invaded. Rhizomorphlike mats develop on the outer dead parts and produce sporophores on the accumulated debris at ground level. The caps of these mushrooms are brown to yellow and 5–15 mm in diameter. The gills on the lower side of the pileus are wide-spaced and nearly white; the stipe is white, attached eccentrically, and 7–9 mm high. The basidiospores are white or hyaline, oval, 1-celled, and $7–9 \times 5–6\ \mu$.

References

9, 10, 12.

Anthracnose, *Gloeosporium musarum* Cke. & Mass.

Symptoms

All aboveground parts of the plant may be affected by the disease. Discolored spots appear most frequently on the leaf petiole and sheath in the pseudostem. The lesions are dark-colored, elongate, slightly sunken, more or less dry, and sometimes expose the vascular fibers. Spots on the leaf blade are brown to bleached gray. They are circular at first, but later become elongate in the direction of the veins.

Etiology

The mycelium is hyaline, septate, branched, mostly intercellular, and causes the tissue to become dark-colored. The acervuli form under the cuticle and emerge by its rupture. The acervuli are pink during wet, humid weather because of the abundance of conidia; in dry weather they are mostly black. They are 150–400 μ in diameter and are crowded with numerous conidiophores, 30–40 μ long. The conidia are hyaline, 1-celled, with 2 vacuoles, 10–15 μ, and usually have rounded ends and parallel sides.

Reference

1.

Stem rot, *Helminthosporium torulosum* (Syd.) Ashby

Symptoms

Small, brown spots with dark centers surrounded by a lighter border are the early indications of the disease. As they increase in size and number, they coalesce into a larger spot that becomes sunken and forms a scarlike injury. The center of the oval, elongate, dark brown to black area becomes covered with the mycelium of the fungus. These sunken, cankerlike areas continue to develop. When several are present, the stem may be more or less girdled and weakened and may lean over.

Etiology

Mycelium develops over the surfaces of the exposed diseased areas and supports conidiophores that are brownish, 48–170 μ high, and 10–15 μ in diameter. The conidia are hyaline becoming smoky olive, crescent-shaped or curved, 6–14-septate, distinctly nodulose, and 25–59 × 8–12 μ. The ascospore stage is *Deightoniella torulosa* (Sydow) Ellis.

References

1, 6, 12.

Stalk rot, *Fusarium moniliforme* Sheldon var. *subglutinans* Wr.

Symptoms

The conspicuous manifestation of the disease is the dying and rotting of the heart leaves. This continues until the downward advancement of the disease reaches the growing point, there killing the plant and causing decay of the rhizome. There is no wilting of the foliage to any extent before the plant is killed.

Etiology

The mycelium is septate and branched; it is more or less colorless, but may be highly colorful, pink to blue and purple, under certain conditions and is variable as to color in culture. The microconidia are 2–5-septate; macroconidia measure 29–61 × 3–5 μ. No chlamydospores are formed.

Reference

8.

Wilt, *Fusarium oxysporum* Schlecht. f. 3. Wr.

Symptoms

The first indication of the disease is inward curling near the tips of the lower leaves followed by a noticeable stunting. Then drooping and wilt begin at the tips and proceed toward the petiole, resulting in yellow to brown discolorations of the blade. More of the older leaves become yellow as new leaves appear. A red to violet color is present in the vascular tissue or corms. Such parts and accompanying roots rapidly decay, and the plant dies.

Etiology

The mycelium is hyaline, white en masse, cottony, branched, and somewhat constricted at the septa. The conidiophores are hyaline, septate, and branched in whorls. Microconidia are hyaline, 1–2-celled, mostly nonseptate, and average 8–9 × 3–4 × 3–5 μ. Chlamydospores are produced abundantly in culture and measure 5–7 × 3–6 μ.

Reference

3.

Vascular disease, *Fusarium oxysporum* f. sp. *cubense* (E. F. Sm.) Wr.

Symptoms

The sheaths composing the pseudostem may show some external discoloration, pointing to internal symptoms of the disease. Leaves sometimes show streaks of rusty-colored tissue following the veins from the midrib to the leaf margins. Often the leaves seem to be bunched, as caused by a shortening of the internodes; thus, the plant appears stunted. In many cases there is only slight internal vascular discoloration. Some longitudinal splitting of the sheaths or leaf bases occurs. New stems may grow out and away from diseased plants. During the decorticating process, diseased plants exhibit greater difficulty in the separation of the fibers from the vascular tissue, and these tissues possess decreased tensile strength. Diseased fibers are distinctly fuzzy. Laboratory studies and cross inoculations have shown that there is some doubt as to the similarity of this vascular disease and Panama disease of banana. These experiments show also that there is a wide variation in resistance to this disease among abaca selections.

Etiology

The mycelium is hyaline, white when dense and felted, and in culture may become bluish or rose red, depending on the medium. It is branched, septate, and produces sporodochia. The microconidia are produced in heads abstricted from tips of secondary branches and enclosed in mucilage. They are hyaline, oval, 1-celled, and $5\text{–}8 \times 2\text{–}3$ μ. The macroconidia are formed on short conidiophores clustered in sporodochia. They are hyaline, mildy bent, mostly septate, while some are up to 5-septate, and $20\text{–}30 \times 4\text{–}5$ μ. Chlamydospores are oval, thick-walled, granular, and 9×7 μ.

References

11, 12.

Other fungi associated with abaca

Botryodiplodia theobromae Patouillard
Cercospora musae Zimmermann
Erwinia carotovora (Jones) Holland
Macrophoma musae (Cooke) Berlese & Voglino
Macrophomina phaseolina (Tassi) Goidanich
Phytophthora parasitica Dastur
Pythium butleri Subramaniam
Sclerotium rolfsii Saccardo
Thielaviopsis paradoxa (De Seynes) Hoehnel
Ustilaginoidella musaeperdae Essed