Plant Ailments

Plants, like man and animals, are subject to myriad diseases. Moreover, there is no single kind of plant that is not affected by some disease.

Plant ailments are older than man. We know this because fossils that predate man's appearance on earth show evidence of such ailments.

As long ago as 700 B.C. man attempted to control plant ailments. The Romans later instituted the feast Robigalia to appease the rust gods with prayers and sacrifice.

In 1660, nearly 200 years before the true nature of wheat rust was known, a law was passed in Rouen, France, requiring the eradication of barberry in order to control rust. At that time some connection between the rust and the shrub had been established but it was not known that barberry was an alternate host of the fungus. Later, in 1726 and 1766 several New England states passed laws to suppress the spread of the common barberry.

Development of the science of plant pathology in the United States in the past 100 years parallels the development of botanical gardens and arboreta.

For some years the federal government maintained a commissioner of agriculture under whose jurisdiction were several divisions, including the Botanical Division. A section of Mycology of this division was established in 1881, and F. Lamson Scribner was appointed as the mycologist, with Erwin F. Smith as his assistant. This represented the first official recognition of the science of phytopathology in the United States, for the work had to do primarily with the diseases in plants.

The early research on plant diseases was conducted largely by federal and state plant pathologists.

In 1881 T. J. Burrill in Illinois demonstrated that the fire blight disease of apples, pears, and other members of the Rosaceae is caused by the bacterium *Erwinia amylovora*. Ten years later M. B. Waite proved that bees and wasps could spread the causal organism.

In 1912 passage of the Quarantine Act officially prohibited the importation into the United States of certain plants and soils in a belated attempt to reduce the possibility of introducing pests and diseases from other parts of the world. By this time the white pine blister rust fungus had already been introduced on low-priced pine seedlings from Europe.

Today, more than 35,000 different diseases affect our economic plants — those used as food, feeds, fibers, and lumber. The number of known diseases of wheat in the United States, for example, is conservatively estimated at 100; of apple at 125; and of potato at nearly 100.

Nor are such large numbers of ailments confined to plants producing food, fiber and lumber. Shade and ornamental trees and shrubs as well as flowers are also subject to many diseases.

The average annual loss from plant diseases in the United States is estimated to be between 3 and 4 billion dollars.

Causes of Plant Ailments

There are two major causes of plant diseases — nonparasitic and parasitic.

Among the nonparasitic causes are mineral deficiencies, chemical injuries, and unfavorable water relationships.

Mineral Deficiencies. All plants need a balanced diet to do well. Those grown in soil which lacks one of the so-called major elements — nitrogen, phosphorus, or potash — or one or more of the essential minor elements, such as iron, boron, or magnesium, will not be normal.

The foliage of rhododendrons, mountain-laurel, and andromeda (*Pieris*) may turn yellow (chlorotic) because of a lack of available iron, which may, in turn, be due to excessive lime. This commonly occurs when these acid-loving plants are planted near a cement wall. Many trees, including pin oaks, cottonwood, boxelder, and sweet gum (*Liquidambar styfaciflua*), also become chlorotic because of the unavailability of iron. Incorporating a so-called iron chelate into the soil or spraying it on the leaves helps to overcome such a deficiency.

Chemical Injuries. Faulty application of nitrate, of potash, or of acid or alkaline fertilizers often brings on symptoms similar to those caused by parasitic organisms. If an excess of sodium nitrate is supplied during dry weather, for example, the foliage at the tops of the plants becomes brown and appears scorched.

Careless use of weed killers also may result in severe damage or even death of trees and shrubs. Weed-killing materials containing arsenicals or the hormone 2, 4-D should be used with extreme care.

Rock salt (sodium chloride) scattered over sidewalks or along roadways to melt ice and snow or prevent water from freezing also causes severe damage to plants growing nearby.

Trees and shrubs growing along large bodies of salt water are often injured by wind-blown salt spray. During hurricanes the spray can actually damage foliage 50 miles from salt water. Smoke emanating from chimneys of manufacturing plants, apartment house incinerators, and other instruments of combustion, including automobiles, contains ingredients which are harmful to vegetation.

The three major pollutants released by manufacturing plants are sulfur dioxide, fluorine compounds, and the smog typical of urban areas. Maple and other broad-leaved trees exposed to high concentrations of sulfur dioxide, for instance, show ivory-white markings, mostly between the main veins; whereas Douglas fir and ponderosa pine exhibit a reddish discoloration of the needles followed by a shriveling of the affected tissues.

Unfavorable Water Relationships. A deficiency of moisture in the soil may result in the scorching of leaves. In such cases the leaves wilt when water lost through transpiration cannot be quickly replaced. Winter injury of broad-leaved evergreens occurs, for example, when the leaves lose more water than can be replaced via the roots while the soil is still frozen in late winter or early spring. In summer, the blossom-end rot of tomatoes is caused by a combination of insufficient moisture and a deficiency of calcium in the soil.

An excessive amount of water in the soil is another non-parasitic cause of some plant ailments. Yews (*Taxus* spp.), for example, are extremely susceptible to an overly wet soil. Research at Rutgers University revealed that yews could be killed by immersing their roots in water-saturated soil for 32 to 64 hours and then drying out the soil.

Parasitic Causes

Fungi, bacteria, nemas (nematodes), and ultramicroscopic entities known as viruses and mycoplasmas are the five parasitic causes of plant ailments. The last, mycoplasmas, are half way in size between viruses and bacteria. Some diseases such as aster yellows and witches' brooms formerly thought to be due to viruses are now known to be caused by mycoplasmas.

Let me briefly review the history and present status of some of the more important diseases of trees that have become widespread in the United States since the founding of the Arnold Arboretum a century ago.

Chestnut Blight

The rapid disappearance of one of our best forest, ornamental, and nut trees, the American chestnut (*Castanea dentata*), as a result of infection by the fungus *Endothia parasitica* is too well known to warrant much discussion today. Despite tireless effort and tremendous monetary expenditures, dead and diseased chestnut trees are all that remain of the losing battle man has waged to check this invader.

No one will dispute the statement that the chestnut blight disease has done more than any other single factor in American history to make the public tree-conscious. Within a span of 60 years many persons have witnessed the passing of this irreplaceable tree. Believed to be of minor importance when first reported by the late Herman Merkel, who found a few infected trees in Bronx Park, New York City, in 1904, the disease proceeded to wipe out the chestnut stands in New England forests and along the eastern slope of the Allegheny and Blue Ridge mountains, the principal range of this host. Today some chestnuts still stand in the extreme southern and western parts of this tree's natural range: in Tennessee, Georgia, and South Carolina. It is safe to say, however, that they too will soon suffer the same fate as their northern kin, for blight has been reported in all these states.

Dutch Elm Disease

The second most widely publicized disease in the last 35 years is the Dutch elm disease caused by the fungus *Ceratocystis ulmi*. The misleading name given the disease merely refers to the Netherlands, where it was first identified in 1919. The disease is believed to have entered the United States in the late 1920's on burled elm logs from Europe. After killing literally thousands of elms in the eastern United States, it has spread to the deep South, the Middle West, and Canada. The disease has been found in at least 33 states, the westernmost being Idaho.

Conditions are ripe, however, for the spread of the disease to California. The principal carrier of the causal fungus, the smaller European elm bark beetle *Scolytus multistriatus*, has been found in 20 California counties.

Many claims of cures or preventives have been made in recent years. However, as of now not one has been substantiated. I have worked with this disease since 1933 when I was in charge of the eradication campaign on Long Island. I have used many of the materials suggested as cures or preventives but found them all wanting.

Among a number of elm species introduced from Asia, the most resistant (though not immune) are the Siberian elm (*Ulmus pumila*) and the Chinese elm (*U. parvifolia*). Unfortunately they lack the qualities that have made the American elm so great a favorite over the past century, particularly in the New England states.

One of the latest efforts to control the disease on American elm seedlings has been exposure to thermal neutrons or x-rays. Four of 150,000 treated trees showed increased resistance, and one has withstood nine inoculations of the fungus *Ceratocystis ulmi*.

A sex attractant produced by virgin female elm bark beetles is also being investigated. If this substance can be produced synthetically in the laboratory, it may help to lure male bark beetles into traps where they can be killed or sterilized by any one of several methods.

A new approach is to use predators to control the insect vector. A wasp-like insect (*Dendrosoter protuberans*), introduced from Europe, lays its eggs in dead or dying elms infested with the larvae of bark beetles. The young hatching from the predator's eggs attack and kill the bark beetle larvae. Whether or not this predator can become sufficiently well-established to cause an appreciable reduction in the bark beetle population remains to be seen.

The use of systemic chemicals which are either injected into elm trunks or applied to the soil in the root feeding zone has been tried by several investigators. It was hoped that such chemicals would move up into the branches and twigs in sufficient amounts to kill the bark beetles which spread the causal fungus.

Encouraging results have recently been reported from the use of Benlate. In fact, only a few months ago, the du Pont Company, manufacturers of this fungicide, received clearance from the federal regulatory agencies to permit its use as an aid in the control of Dutch elm disease.

Benlate is applied as a foliar spray or is injected into the trunk of the tree.

As a foliar spray, it is used at the rate of 8 pounds in 100 gallons of water in spring when the leaves are fully formed. This is the time the bark beetles begin to feed.

As a trunk injection, it is used at the rate of 2 pounds per 100 gallons of water. Injector tubes equipped with cups of approximately 2 fluid ounce capacity are inserted into the outer growth rings just deep enough to prevent leaking at the point of entry. The injector tubes are spaced at 2-inch intervals around the trunk. The cups are filled and left in place for 24 to 48 hours. They are refilled as needed. The injector tubes are removed when the treatment is completed.

The Benlate treatment must be given by a trained arborist.

It is to be hoped that this treatment combined with a sanitation and insect control program will be successful in slowing down this highly destructive disease.

Phloem Necrosis

Even more deadly than the fungus-induced Dutch elm disease is phloem necrosis. This disease was once thought to be caused by a virus but it is now known to be caused by a mycoplasma. Thousands of elms in the Middle West along the Ohio River basin have died from its effects in the past 30 years.

Just recently phloem necrosis has appeared in the western and central parts of New York State. It is only a matter of time before it will reach New England to destroy those elms that have thus far escaped the Dutch elm disease.

The phloem necrosis organism can be transmitted experimentally by grafting patches of diseased bark, scions or roots on healthy trees. In nature the infectious principal is transmitted by the elm leafhopper *Scaphoideus luteolus*. Because of the nature of the causal organism, there is a possibility that control of infected trees can be achieved by using an antibiotic such as tetracycline.

Oak Wilt

Another highly publicized disease, wilt, of oaks, is causing some concern to arborists, nurserymen, tree owners, and lumber interests in the Middle West. The disease has been found in 20 states from Kansas and Nebraska eastward to Pennsylvania, and from Minnesota southward to Texas.

The fungus *Ceratocystis fagacearum* is known to cause wilt. It is spread by root grafts and by several insects including fruit flies; Nitidulid beetles; the flat-headed borer, *Chrysobothris femorata*; and two species of oak bark beetles, *Pseudopityophthorus minutissimus* and *P. pruinosus*. The fungus can also be transmitted on tools used by arborists and foresters.

No effective control of wilt is known. For the present, eradication and burning of infected specimens is being advocated. Because the oak wilt fungus appears to be most infectious early in the growing season when the new spring wood vessels are developing, it is suggested that pruning operations in oaks be delayed until July or later.

Ash Dieback

In the northeastern United States, white ash (*Fraxinus americana*) has been affected by a branch dieback, and since 1940 occasional death of some of the affected trees has been noted. Dr. Craig Hibben at the Kitchawan Research Laboratory of the Brooklyn Botanic Garden found that a strain of tobacco ringspot virus was associated with leaves exhibiting early symptoms of ash dieback.

In addition, Dr. Hibben was successful in transmitting a mycoplasma-like organism from declining white ash trees showing witches' broom symptoms to healthy ash trees by means of the parasitic flowering plant known as dodder (*Cuscuta* sp.).

Although much research still must be done, these discoveries should eventually help to solve some very serious problems on white ash.

(The wood of white ash, by the way, is used to make baseball bats for America's favorite sport.)

Other important contributions on plant diseases have been made by arboreta and botanical gardens over the years. A brief review of some of these may be in order here.

At the Arnold Arboretum, more than 40 years ago, a forest pathologist, Dr. J. Horace Faull, was first to recognize the occurrence of the Dutch elm disease in the United States and warned of the potential danger of this disease to elms. Unfortunately his many warnings went unheeded. More widely recognized was the herbarium of specimens of diseases of native and cultivated plants prepared by Dr. Faull, his co-workers, and students.

Alfred Fordham, plant propagator at the Arboretum, found that many woody plants which failed to grow in spring died not from so-called winterkill but from the first sharp freeze in autumn. The bark of susceptible plants is ruptured and separates from the wood, resulting in death of the plant.

Donald Wyman, Horticulturist, Emeritus, at the Arnold Arboretum, found that some trees are unusually susceptible to certain pests and diseases and suggested that they should not be planted in areas where they cannot receive adequate care. He recommends, instead, the planting of trees that are unusually pest-free. Included in this group are: *Carpinus* species, *Cercidiphyllum japonicum, Eucommia ulmoides, Franklinia alatamaha, Ginkgo biloba, Gymnocladus dioicus, Koelreuteria paniculata, Liquidambar styraciflua, Phellodendron* species, and *Sophora japonica.*

At the Brooklyn Botanic Garden, classical research on virus diseases has been conducted since the early 1940's, starting with Dr. L. M. Black and continuing with Doctors Karl Maramorosch, Myron K. Brakke and Walter Tulecke. Brakke's work on density gradient centrifugation was responsible for a new approach to the separation and identification of viruses. The contributions made more recently by Dr. Craig Hibben have already been noted in my discussion of ash dieback.

At the Cornell University Arboretum, now known as The Cornell Plantations, hundreds of elms are being grown to determine their resistance to the Dutch elm disease fungus.

At the Missouri Botanical Garden, early in this century Dr. B. M. Duggar contributed to the understanding of the future of viruses by measuring the tobacco mosaic particle. The garden also pioneered in the growing of mushrooms from pure culture spawn, transforming mushroom production into a profitable industry. In the 1930's A. P. Beilman made many contributions to the care of shade trees.

At the National Arboretum in Washington, D.C., Frank S. Santamour, Jr., research geneticist, has discovered the first natural hybrid between the tetraploid American elm and the highly resistant diploid Siberian elm.[1] More recently, another triploid elm, a hybrid of *U. pumila* and *U. rubra*, was found through cytological research.[2] According to Dr. Santamour, "It is likely that triploids created by crossing diploids with colchicine-induced tetraploids will be partially fertile and be useful in further breeding for resistance to Dutch elm disease".

There is one discouraging aspect in the development of plants resistant to fungi and other parasites. It is now well established that a plant resistant to one strain of a fungus may succumb to another strain of the same fungus. This has been shown in the development of varieties of wheat resistant to the rust fungus *Puccinia graminis*. The same situation holds for the fungus *Ceratocystis ulmi*, the cause of the Dutch elm disease. There are strains, particularly one known as the black line strain because it produces a black growth at its perimeter of growth in culture, that are extremely virulent and capable of killing an elm within a year of infection. Other strains are less virulent and may take three or more years to cause death.

Important contributions have also been made by the New York Botanical Garden. Pioneer work on the cytology and genet-

[1] Santamour, Frank S., Jr. 1970. A natural hybrid between American and Siberian elms. Forest Sci. 16: 149–153.

[2] Santamour, Frank S., Jr. 1971. A triploid elm (*Ulmus pumila* × *U. rubra*) and its aneuploid progeny. Bull. Torrey Bot. Club 98: 310–314.

ics of the fungus *Neurospora sitophila* was done by my predecessor, Dr. B. O. Dodge. This was followed by the work of other geneticists that resulted in the discovery of the chemical affinities of chromosomes and genes. For their part in these researches Doctors G. W. Beadle, J. Lederberg, and E. L. Tatum received the Nobel prize in medicine in 1958.

Other contributions made by the New York Botanical Garden, directly or indirectly related to plant ailments, include the effect of natural gas on trees, and the application of plant nutrients directly to the foliage of trees and shrubs.

The newly established 1800-acre Cary Arboretum of the New York Botanical Garden at Millbrook, N.Y., has among its objectives the finding of a replacement of the fast disappearing American elm, the mass planting of all elm species to assess their relative resistance to the Dutch elm disease, and the testing of blight-resistant clones of the American chestnut.

Thus down through the years, the study of plant ailments and their control continues to progress. Modern research at botanical gardens and arboreta such as the Arnold Arboretum is a far cry from the efforts of the ancient Romans to appease the rust gods with prayers and sacrifice.

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