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Chestnut Blight

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The chestnut blight, believed to have been brought into North America on Asiatic chestnut planting stock, is the most destructive forest disease known. The fungus that causes the disease (*Endothia parasitica* (Murr.) A. & A.) was discovered in 1904 in the New York Zoological Park. The blight spread fast (fig. 1). In less than 50 years it swept throughout the natural range of the American chestnut tree (*Castanea dentata* (Marsh.) Borkh.)—roughly the eastern third of the United States from the Canadian border south nearly to the Gulf of Mexico.

The blight destroyed the equivalent of more than 9 million acres of chestnut forest. For the industries that relied upon the American

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Figure 1.—A stand of chestnut trees dying from chestnut blight. (Long Island, N.Y., 1907.)

chestnut for lumber, cooperage, tannin, fiberboard, and nuts, this was disaster. Some of these industries soon ceased to exist; others turned to less valuable and slower growing hardwood species for their lumber supplies. The tanning industry subsisted for about 20 years by salvaging the tannin from the dead chestnut trees.

The blight also spread outside the natural range of the chestnut, in the Midwest and West. It has been reported on trees planted in California, Oregon, and Washington, as well as in Illinois, Iowa, Michigan, Missouri, and Wisconsin. Though some large, old, living trees still unaffected can be found in these regions, they too may eventually succumb to the blight.

Hosts

The hosts most susceptible to the blight fungus are the American chestnut and the European chestnut (*Castanea sativa* Mill.), the American being a little more so than the European. The native chinkapin species of the Eastern United States also are susceptible.

In the Eastern United States the fungus has damaged post oak (*Quercus stellata* Wangenh.). It has been reported on maples, hickory, and sumac, although causing little damage to these species.

In Europe, three European oak species (*Quercus ilex* L., *Q. petraea* (Mattuschka) Lieblein, and *Q. pubescens* Willd.) are subject to blight attack, along with the European (or Italian) chestnut.

In Asia the four chestnut species—Chinese chestnut (*Castanea mollissima* Bl.), Henry chinkapin (*C. henryi* (Skan) Rehd. & Wils.), Japanese chestnut (*C. crenata* Sieb. & Zucc.), and Seguin chestnut (*C. seguinii* Dode.)—all serve as hosts to the fungus, but show varying degrees of blight resistance. Of these, the Chinese chestnut is the most blight resistant.

Symptoms

The most pronounced early symptom of the disease on a chestnut tree is an occasional "flag," a dead branch with yellow or brown wilted leaves. A girdling canker is usually found on the branch below the discolored foliage. If the girdling occurs early in spring, the dead foliage is only half normal size.

If the canker occurs at the base of a tree or sprout, the entire part above may be killed outright. However, new sprouts readily develop below the basal cankers at ground level because *Endothia parasitica* does not infect the host parts below ground. These sprouts in turn become blighted, but not so soon because now there are fewer *E. parasitica* spores present to cause infection.

Young cankers on smooth-barked, vigorous young stems are yellowish brown on the surface. The cankers may be sunken or swollen (fig. 2).

The fruiting pustules on the cankered bark are yellow, orange, or reddish brown, and are the size of a pinhead. In damp weather, sticky spore masses exude from some of the pustules (pycnidia) as twisted, yellowish-orange tendrils or spore horns (fig. 3).

On large stems with thick fissured bark, the disease is difficult to detect until longitudinal splits appear or fruiting pustules develop in the bark fissures. In addition to the wilting foliage, cankers, and fruiting pustules associated with the disease, mycelial fans can be seen readily when the overlying bark at the edge of an active canker is removed.

Chestnut blight symptoms on resistant oriental species of chestnut and on resistant chestnut hybrids differ from those on susceptible trees. Sometimes a canker may

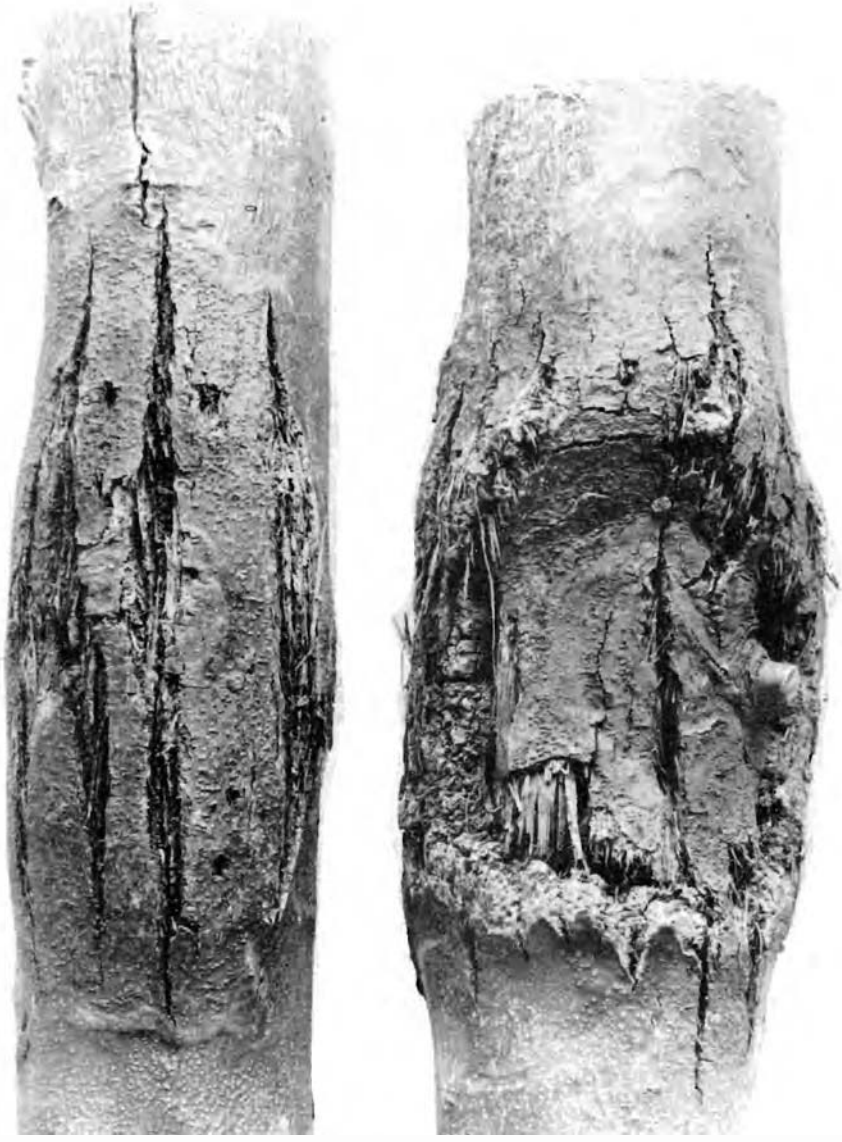

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Figure 2.—Chestnut blight cankers of the swollen and sunken types on stems of American chestnut. Note the abundant fruiting pustules on the cankered bark.

develop on a branch or trunk and eventually cause the affected host part to become suppressed, indicating that all the tissue underneath it has been killed. On resistant trees this type of canker rarely girdles the stem; and the open canker, if not too large, may be closed over by growing bark. In other instances the canker may be swollen, indicating that the fungus has not killed the tissue beneath.

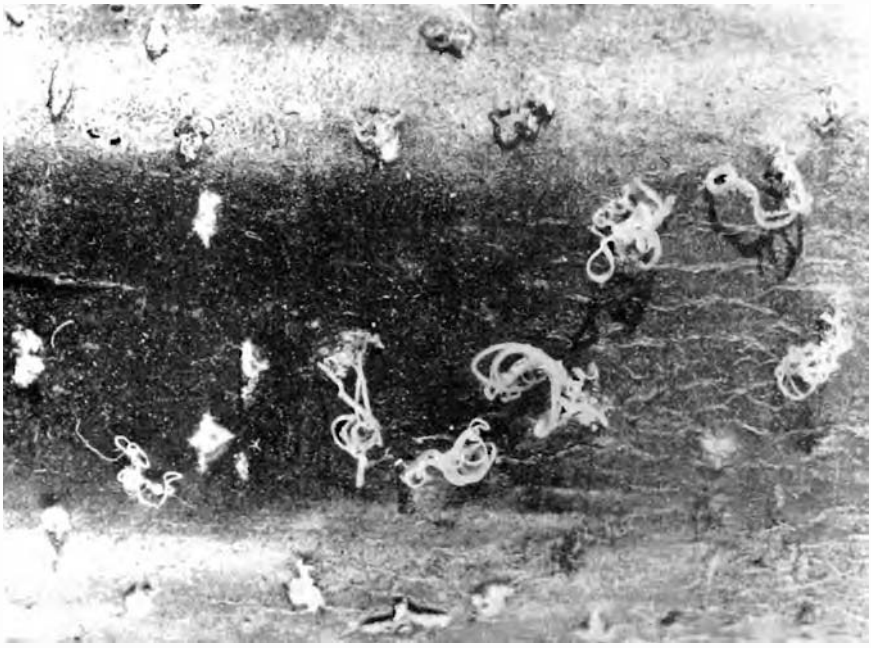

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Figure 3.—A blight-infected American chestnut stem bearing twisted tendrils, or spore horns, which ooze out of some of the pustules (pycnidia) during damp weather. (Magnified approximately 6 diameters.)

This type of canker may encompass the affected host part, but rarely will it kill the tree. Blight-resistant trees often outgrow this type of canker, which rarely forms fruiting pustules.

The Fungus

The causal organism, *Endothia parasitica*, is a wound parasite. It can infect the bark only when its spores lodge in wounds that are deep enough to expose the live inner bark and cortex. The fungus spores, upon germination, develop mycelia that rapidly penetrate the inner bark and cambial layer. After the fungus has grown under the outer bark for some time, minute pimple-like pustules erupt through the surface bark.

These fruiting pustules are of two kinds. One, called pycnidia, produces tiny, one-celled, sticky conidiospores that ooze out in long, twisted tendrils during moist weather (fig. 3). These conidiospores are disseminated by birds, crawling or flying insects, or by splashing rain. The other kind, called perithecia, produces slightly larger, two-celled ascospores that are shot into the air through a small opening at the top of the pustule. Ascospores are windborne and may be carried for miles, but they are relatively short lived.

When a tree has been killed by chestnut blight, the fungus may continue to invade the inner bark and cambium of the dead host and produce many pycnidia and peri-

thecia that yield viable spores. The pustules can also develop on the bark of logs or fallen trees.

Search for a Resistant Tree

Despite intensive efforts by the Federal Government, State and private agencies, and individuals, no method for controlling the chestnut blight has been found.

When it became apparent that the early spread of the blight could not be checked by eradicating the affected trees, three new, long-range approaches were adopted instead:

1. Search the Orient for a blight-resistant chestnut tree that might prove to be a suitable substitute for the American chestnut.
2. Among the persistently sprouting American chestnut trees, search for a seedling bud variation that might possess a high degree of blight resistance or possibly immunity, and propagate it.
3. Develop a forest-type of blight-resistant hybrid chestnut tree, utilizing all available germ plasm as source material.

Progress in the search for a resistant chestnut tree has been slow. By the middle 1920's, when the disease had reached the heavily chestnut-populated forests of North Carolina and Tennessee, the U.S. Department of Agriculture sent an expedition to the Orient in search for blight-resistant chestnut trees that might serve as suitable substitutes for our blight-susceptible American species. At the same time, a search was begun for resistant American chestnut trees of seedling or sprout origin—a search that has continued to the present. And a chestnut-tree-breeding program, begun in 1925, still continues even though early attempts to produce blight-resistant American-Asiatic hybrids demonstrated that some crosses with as little as one-fourth American chestnut parentage are highly susceptible to *Endothia* attack.

Present Status

The best Asiatic chestnut discovered thus far, as determined by 25 years' performance of more than 28,000 Asiatic chestnuts in 21 test plots, is Chinese chestnut P.I. 58602. The original introduction, received in the autumn of 1924 from Nanking University, consisted of 200 pounds of seed. The resulting seedlings were distributed to approximately 50 field cooperators throughout the Eastern United States in the spring of 1926. From a few of these early plantings many ¼-acre demonstration plots have been established in every State east of the Mississippi River except Florida, and in Iowa, Missouri, and Arkansas, in the past 15 years.

In forest-tree form, size, winter hardiness, and disease resistance, this introduction from Nanking has proved superior to all other Asiatic chestnuts tested. In the past 7 years, the Eastern Region of the U.S. Forest Service has used this introduction exclusively on five national forests in an extensive planting program to improve wildlife habitat. Even though direct importation of chestnuts from the Orient was terminated in 1949, a steady source of seed for future needs seems assured.

In an attempt to discover if a natural resistance to the fungus *Endothia parasitica* may be developing in some of the larger surviving trees, more than 500 American chestnut trees, 8 inches d.b.h. or over, have been tested for blight resistance throughout an 11-year period. More than 90 percent of these trees have succumbed to the blight. However, none of the survivors can be recommended for ex-

tensive planting until it has withstood repeated infections of the fungus through artificial inoculations.

In the tree-breeding program, several very promising blight-resistant, forest-type chestnut hybrids have been developed at both the Connecticut Agricultural Experiment Station and the U.S. Plant Industry Station at Beltsville, Md. However, these must be propagated more extensively before they can be made available for general distribution, and they must be tested under a variety of field conditions before they can be recommended for widespread use.

Discussion

Extensive tests conducted throughout the Eastern United States have shown that the optimum range of Asiatic chestnuts (imports from China, Japan, Korea, and Formosa) does not coincide exactly with the range of the American chestnut and the native chinkapin species. In their site requirements, Asiatic chestnuts are more nearly like our native yellow-poplar, northern red oak, and white ash than the American chestnut and the native chinkapins. Asiatic chestnuts are best adapted to northeastern slopes, above frost pockets; on cool protected sites; on fertile, well-aerated soils that have a layer of leaf litter and humus on the soil surface; on soils that are permeable to both roots and water, and that have good water-holding capacity. Such sites occur in rich soils of slight hollows, in moist hilly woods, and in mountain coves.

When planted west of the Appalachians and in northern Pennsylvania, New York, and the New England States, Japanese chestnut, Seguin chestnut, and the forest-tree Henry chinkapin were winter killed during the first season. And even the most winter-hardy Chinese chestnut (P.I. 58602) from Nanking, which successfully withstood winter conditions in the beech-maple forest type of northwestern Pennsylvania for as long as 15 years, eventually failed because of snow and ice breakage.

On the other hand, the Chinese chestnut appears to have a much wider range of adaptability. It is doing well in the Midwest, especially in southern Ohio, Indiana, Illinois, and southeastern Missouri—areas where the American chestnut occurred infrequently or not at all.

American chestnut sprouts still occur throughout our eastern forests, and some live long enough to gain tree size before they are killed by the blight. That these sprouts live as long as they do can be attributed to the great reduction in the amount of inoculum in our forests. There is still reason to hope that a blight-resistant sport or mutant American chestnut will be discovered.

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