TREES FIGHT BACK[1]

by Carl H. Beckman

When we humans get a sore throat, a cut or a blister, the reddening or inflammation that appears is part of a process of defense and healing. Without this process, we would die from the slightest injury of infection.

So it is, also, with higher plants. Although they differ in many respects from warm-blooded animals, many of their cellular functions are similar. Plants are beset by all sorts of injuries that become infected. Roots become chewed by insects, torn by golf shoes and hoes, while stems are cut and punctured and torn by high winds, by sapsuckers, by apple pickers, and by little boys with jackknives. All of these injuries become readily infected. Plants have their own systems of defense, however. Without them, tomatoes and cabbages and potatoes and elms would not exist.

One such defense process involves the conductive system of plants. Unlike humans, who have a single blood stream with a heart to provide circulation, plants have two separate systems. One flows upward carrying water and soil nutrients from the roots to the leaves, while the other system carries foodstuffs downward from the leaves, where they are manufactured, to all other parts of the plant.

The water and nutrient system is formed by long, living cells that are laid down end to end. These cells deposit special materials as ridges in the wall so that the wall membranes are reinforced. Then the contents of the cells dissolve, leaving long, open tubes with reinforced side walls and occasional reinforced end walls that now form screen-like grids across the tubes.

The energy for carrying the water upward in the plant is provided by the sun. As the sunlight strikes leaves, it causes evaporation of water from them. This evaporation sets up a suction that is transmitted throughout the minute water columns to the smallest rootlet and causes the upward flow of water through the system.

Injuries and infections of the water-conducting systems are an everyday occurrence in the life of a plant. With such an open system, the danger is that infectious organisms will get in and be carried quickly up the superhighways that the water vessels provide. Germs do get in, but fortunately those sections of the superhighway that are infected are usually sealed off quickly. Since there is normally a much larger transport network than is needed, and since new lines are being laid down all during the growth period, the continued sealing off does not ordinarily harm the plant.

This defense process, how it works and what happens when it fails, has been identified and studied by researchers of the Rhode Island Agricultural Experiment Station with financial support from the U.S. Departments of Agriculture, and Health, Education and Welfare. The

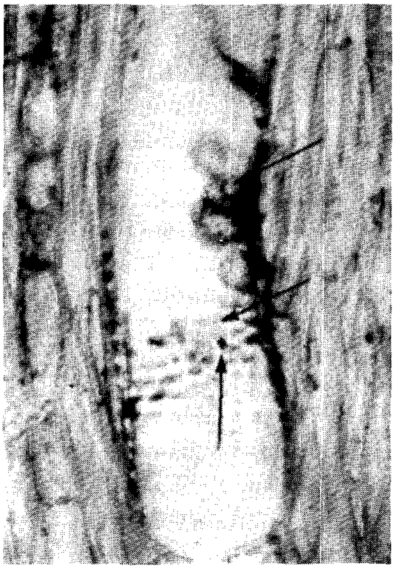

Fig. 1. Early stages of a plant's defense are shown in photo taken through a microscope that has magnified a tubule about 350 times. A minute spore has been trapped on a cross grid (bottom arrow), gel has formed immediately above the grid (middle arrow) and the walling-off process has begun (upper arrow).

1 Reprinted from *Rhode Island Resources*, Winter 1973.

battle between an infecting organism and a plant, we find, is a race between the invading forces and the defensive forces, with all sorts of weaponry involved.

Let us assume that a grub has chewed a hole in a root of a tomato plant. Since there are thousands of single-celled spores (seed) of microorganisms in the soil water, some of these are quickly sucked into the wound and up into the tube system. These spores are the mobile units for many parasites and they literally race up the tube network until they reach the first of the many gridded cross-walls. Here further progress stops until the spore can send out a growth strand to penetrate the cross-wall and produce another mobile spore on the upper side of the membrane. The new spore then is in a position to race off to the next grid. This process takes about two days.

In the meantime, however, the first in a series of three defensive weapons is brought into play by the plant. First, the membranes of the side walls and the grid itself are caused to swell until the tubule is filled with a jelly-like substance much like apple jelly. The new-formed spores of the parasite are made immobile in this jelly. The parasite begins to produce enzymes that chemically chew up the jelly, but by now a second defensive process is well underway. This process involves a rapid growth of living cells that surround the tubules. Sack-like growths push into the infected vessel from all sides until it is completely walled off. Finally, chemical substances, called phenols, are released from specialized cells that store them, apparently for just such an emergency. The phenols serve to tan the whole new structure, much as shoes are tanned, so that it is highly resistant to chemical and physical wear and tear. This is how the defensive forces of the plant win the fight, as they do most of the time, day in and day out.

There are certain instances, however, in which the plant loses the battle. When a susceptible plant is invaded by a virulent parasite under suitable temperature conditions, the well-integrated defense system becomes disrupted. The gel forms, but it doesn't persist for more than a day. The sack-like outgrowths begin to form, but then their development is delayed for several days. In the meantime, the spores of the parasite leapfrog from cross-grid to cross-grid until the advancing wave of the parasite has outrun all of the active defense systems of the plant.

Eventually, the defensive forces do get the tubules sealed off, but only after the invading forces have advanced throughout the whole water-conducting system. When the defense finally comes into play, it seals off the whole water-conducting system. The water-conducting tissues then cannot carry sufficient water to meet the plant's needs. If the resulting water shortage is only moderate, involving only a portion of the conductive tissue, the plant's growth will be stunted and some branches may die. But if the shortage is severe, the plant will wilt and die. This is how American elms die when they become infected with the Dutch elm disease

The fortunate fact, however, is that the defense systems of most plants work effectively most of the time, or forests, farms, and front lawns would not exist. Where they do not work, plant scientists are busily breeding stronger resistance processes into those plants that are important to us. This is being done with elms, potatoes, cotton, and bananas, and many other crops all around the world, to provide better and more reliable crops for the future.

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