For example, Yehezkel Antignus and his colleagues at the Volcani Center in Bet Dagan, Israel, are testing ultraviolet (UV)-absorbing, clear plastic films to protect greenhouse crops against virus-carrying insects, such as aphids, white flies, and thrips.

Kibbutz workers first noticed that tomatoes grown under such plastic to protect them from burning by the sun escaped viral diseases. A study of insect behavior beneath the plastic revealed why: It disrupts the spread of microbes carried by insects that need UV light to navigate. "By interfering with vision behavior, contact between the vector and the plant may be prevented, and, therefore, virus spread is decreased," says Antignus.

Clear plastic can also help when used to cover the soil for 3 to 6 weeks before crops are planted. During this period, temperatures can rise to about 50 degrees Celsius, enough to kill some fungal spores, weed seeds, and nematodes. The technique has been used in Florida to protect vegetables and ornamentals, in Egypt and Italy to protect tomatoes and carnations, and in Italy and Turkey to protect peppers. In some cases, this technique replaces synthetic chemicals that are being banned or restricted, says plant pathologist R. J. McGovern of the University of Florida, Bradenton.

But despite the wide range of pest-control strategies under development, researchers know that they, like the Red Queen in *Alice's Adventures in Wonderland*, have to keep running just to stay in place. History has shown that no control, no matter how clever, is immune to pest evolution. "The battle against crop pests is ongoing, with short periods of relief when science temporarily gains the advantage," says Berkeley's Schroth. Adds plant pathologist Carolee Bull of the USDA in Salinas, California, who has just begun studies to learn why some organic farming techniques succeed while others fail: "There is an enormous amount of work to be done."

–ANNE SIMON MOFFAT

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NEWS

The Push to Pit Genomics Against Fungal Pathogens

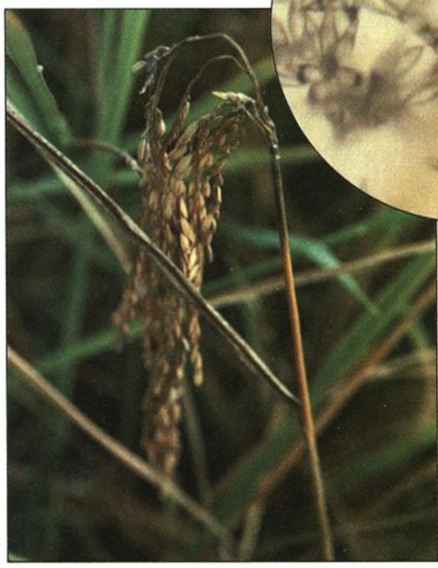
Despite the damage done by these serious plant pests, researchers have barely begun sequencing their genomes

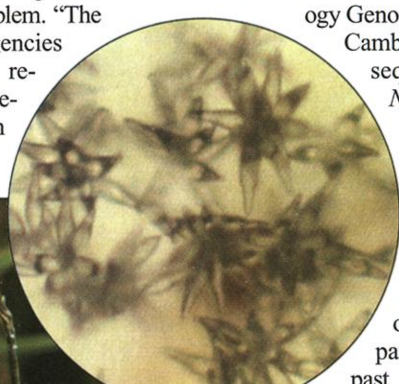
Ask a plant pathologist to draw up a "most wanted" list of dangerous microbes, and, chances are, many fungi would be near the top. Fungi and funguslike organisms called Oomycetes destroy crops, kill trees, ruin lawns and golf courses, and contaminate foods and animal feed with deadly toxins. Their dirty work causes some 10,000 different diseases in plants alone. Notorious examples include the late blight of potatoes, which caused the great Irish famine in the 19th century, and Dutch elm disease, which wiped out many elms in the United States in the mid–20th century. And now, a relative of the late blight potato pathogen, called *Phytophthora*, is taking out century-old live oaks in California.

Given this trail of destruction, most plant pathologists would put fungi near the top of another most wanted list: microbes whose genomes should be sequenced. Determining the complete sequences of pathogenic and nonpathogenic fungi could be a big help in determining what makes some fungi the microbial equivalents of Bonnie and Clyde while others never cause trouble—information that could help in the design of much-needed antifungal agents.

But although academic researchers have sequenced the genomes of dozens of bacteria, including important pathogens such as those causing cholera and Lyme disease, they have so far completed the sequence of only one fungal genome: that of yeast. A few others—such as those of the nonpathogenic bread mold *Neurospora crassa* and white rot fungus, which destroys deadwood—are in draft form. But even the white rot fungus was chosen more to test a new sequencing strategy rather than because of its economic importance. Although several biotech companies are sequencing the genomes of fungal pathogens, what they are learning largely remains behind closed doors. For the most part, "fungi have been left out in the cold," says Ralph Dean, a plant pathologist at North Carolina State University in Raleigh.

Money is the main problem. "The government funding agencies haven't committed the resources to get fungal genomics going," says Olen Yoder, a plant pathologist at the Torrey Mesa Research Institute in La Jolla, California. The National Institutes of Health, the Department of Energy (DOE), and the National Science Foundation (NSF) have poured hundreds of millions of dollars into genome sequencing; the draft of the human genome sequence alone cost more than $300 million. In contrast, plant pathology's fungal camp has had virtually no support. And fungi, with genomes that are several times larger than that of the average bacterium, are relatively expensive to sequence and assemble.





Rice menace. When the spores of the rice blast fungus (*inset*) infect rice plants, they can cause the rice head to droop and die.

PHOTOS BY H. DAVID THURSTON

Still, there are signs that the situation is beginning to improve. As the human genome project winds down, the big sequencing centers are beginning to take an interest in fungal genomes. In September 2000, the Whitehead Institute/Massachusetts Institute of Technology Genome Sequencing Project in Cambridge got NSF support to sequence the genome of *Neurospora crassa.* With that under its belt, the Whitehead would like to start on a new "Fungal Genome Initiative," with the goal of sequencing the genomes of 15 fungi, at least some of which will be plant pathogens. Moreover, this past spring, the U.S. Department of Agriculture (USDA), in conjunction with NSF, initiated a new $9 million program for sequencing the genomes of agricultural and forest pests, which could get the Whitehead's fungal initiative or other fungal sequencing efforts off the ground.

These efforts won't be sufficient by themselves, but they should at least begin to provide plant pathologists with a new arsenal of knowledge for neutralizing the threats that fungi pose to both food crops and ornamental species. And the information could be applicable to much more than plant diseases. Some of the fungi that cause problems in people "are the same pathogens that cause plant diseases," says Ann Vidaver, a plant