POTATOES

Once Again, Under Fungal Attack

BRUCE FRITZ (K7624-1)

Plant physiologist John Helgeson examines potatoes growing at the University of Wisconsin's research station at Hancock. [See "Hybrid Potatoes Survive Blight" on page 13.] Resistant to late blight, this hybrid is also being used in breeding trials at the ARS Vegetable Laboratory, in Beltsville, Maryland.

In ancient times, farmers danced, chanted, and even invoked spells to protect their crops from the ravages of pests and disease.

Fortunately, today's growers are armed with more knowledge about crop diseases and how to control them. Integrated pest management and pesticides greatly increase the odds of winning the war against plant diseases. But as time has brought better weapons, it has also brought more devastating diseases.

"Late blight caused by the fungus *Phytophthora infestans* is an excellent example," says plant pathologist/microbiologist Kenneth L. Deahl, who is with the ARS Vegetable Laboratory in Beltsville, Maryland. "It can destroy a potato crop in a matter of weeks.

"And new strains of the fungus that are now attacking potato crops throughout the world are far more difficult to control than the strain that struck in the 1800s," says Deahl. When this fungal plant disease attacked Ireland's potato crop, half a million people starved, and another million emigrated to North America.

Despite modified cultural practices and fungicides designed to slow the blight down, the new, more severe strains of late blight have spread throughout the world in just 6 years. These strains have sexually produced spores that can live in infected stems, tubers, and soil over winter and be infective the next season.

According to Neil Anderson, University of Minnesota plant pathologist, the more virulent strains of late blight produce spores on plant stems, while the original strains sporulated only on plant leaves. "In the 25 years that I've worked with late blight, I've never seen blight attack tubers like these new strains do," he says.

The new strains of late blight that have appeared in the United States are called US-6, US-7, and US-8, while US-1 is an A1, original strain that can be controlled with the chemical metalaxyl.

Unlike A1, the new A2 strains aren't deterred by this chemical or by imperfectly applied cultural practices, such as immediately culling and destroying infected potatoes.

Since the A2 strains are resistant to metalaxyl, the Environmental Protection Agency allowed emergency use of three other chemicals

against the disease in 1995. Although that helped, isolated epidemics of new, aggressive strains of late blight occurred in 1995 and 1996.

In November 1996, plant pathologist Robert W. Goth and plant geneticist Kathleen G. Haynes, who are also based at the ARS Vegetable Laboratory, released two potato breeding selections that resist the most virulent strains of late blight.

In addition, Goth, along with colleague Judith Keane, has developed a way to test potato leaves for resistance to late blight. Up till now, the only way to find out how well a plant would do was to infect it in field plots and watch for symptoms. This procedure risked spreading the highly contagious blight throughout an entire test area.

"Because late blight had been controlled with chemicals since the middle of the 20th century, breeding for resistance to the disease was not a top priority in the United States," says Haynes. "And all major potato-producing areas of the United States had a blight forecasting and chemical spray program based on weather-oriented models. The fungus thrives in cool, damp weather."

U.S. Department of Agriculture efforts to breed potatoes for race-specific resistance to the disease began in the 1920s. And former ARS plant breeder Ray Webb began the ARS Vegetable Laboratory's breeding program for field resistance to late blight in 1976.

"The two resistant breeding selections that we released were the result of three generations of plant crosses," Haynes says.

"Initially, this germplasm had shown resistance to the severe strains of late blight found in the Toluca Valley, Mexico, but it did not have other characteristics needed to be commercially acceptable."

When grown in the field, the plants produced irregularly shaped potatoes that wouldn't process well into chips or fries. Since Haynes and Goth weren't increasing the level of resistance to the disease with successive breeding, the scientists decided to release the germplasm to other breeders, who they hoped would combine desirable processing and fresh-market characteristics with the late blight resistance in the two ARS selections.

Last year, Haynes gathered 17 potato clones that were reported to have some resistance to late blight. From them, she produced virus-tested plantlets in tissue culture so that minitubers could be distributed to State scientists at eight U.S. locations. The clones came from research programs by ARS, university (Cornell, Minnesota, and Colorado State), and European sponsors.

Haynes worked with scientists from the Universities of Florida, Maine, Minnesota, and Wisconsin, and from Michigan State, North Dakota State, Penn State, and Cornell Universities. They evaluated the level of resistance at each location and ranked the clones from 1 to 17, with 1 being the most resistant to late blight and 17, the least.

"Of the top four clones that showed the most blight resistance, three came out of Beltsville and one from the ARS potato breeding program at Aberdeen, Idaho," Haynes reports. "We only released two of the Beltsville clones and plan more work on the third."

Neil Anderson and his University of Minnesota colleague, Vergel Concibido, field-tested the clones.

"Since we've only had the A2 strain in Minnesota for the last 4 or 5 years, we tested the new clones at our Rosemount Agricultural Experiment Station, which is 80 miles from

SCOTT BAUER (K5458-3)

Plant pathologist Ken Deahl examines a potato damaged by late blight fungus.

SCOTT BAUER (K5454-17)

To ensure continuing availability of this valuable food staple, plant breeders must unite desirable processing and fresh-market characteristics with late blight resistance.

our potato-growing region," Anderson reports. "The new material showed good resistance to the disease and stayed green when other clones were dead from blight. We also had good results from the clones developed at Aberdeen."

Promising Findings

Anderson and Concibido planted the experimental clones close to Norchip, a commercial chipping potato variety, and inoculated Norchip with the severe strains of late blight so the fungus could spread naturally. Anderson reports several important findings from the research.

"Even though some of the clones we evaluated are somewhat susceptible to the disease, they would still require less chemical sprays than commercial varieties," he says.

"This would save growers money and also help cut down on the amount of chemicals released into the environment."

Roger Jones, extension plant pathologist at the University of Minnesota, says that the major problem in trying to control new strains of *P. infestans* is that preventive spraying of pesticides is necessary about every 5 days. Historically, he says, growers sprayed for blight an average of once or twice a season, and that spray regimen worked. But for the new strains, even increasing the number to 8 or 10 applications doesn't always work. So not only are growers incurring more costs, they're putting more chemicals into the environment and still losing.

Late Blight Economics

Just how devastating are these new strains of late blight?

The International Potato Center in Lima, Peru, estimates late blight losses at about $3 billion annually worldwide. In the United States, losses over the past several years are estimated in the hundreds of millions. Potato growers in Washington and Oregon alone lost $30 million in 1995, says Cornell University plant pathologist William E. Fry.

"A good example is a single potato grower in New York who lost $1 million to the new strains of the disease in 1994," says Fry. "Despite a doubling of pesticide expenditures, the disease cut that grower's marketable yields by 80 percent. In addition to defaulting on three supply contracts, the grower had to dispose of 4,090 metric tons of rotting potatoes in an environmentally acceptable way. Needless to say, he is no longer growing potatoes.

"The rate at which these exotic strains of *P. infestans* spread and the severity of the epidemics they produce are astounding," Fry says. "The new strains appeared in the eastern United States beginning in 1992. By 1996, immigrant strains had become established in most of the United States and Canada."

SCOTT BAUER (K5455-7)

Potatoes infected with late blight are purplish and shrunken on the outside, corky and rotted inside.

Test Quickly Measures Resistance

A test developed by Goth and colleague Judith Keane could help slow the onslaught. It can determine in just 6 days if a plant can resist the original—as well as exotic—strains of late blight. In addition to potato plants, it works on tomato plants, which are also a victim of late blight.

By simply detaching leaves from plants and subjecting them to the pathogenic fungus, the scientists can tell if a plant has resistance.

"Testing late blight resistance of plants in a field requires introducing the pathogen and chancing the risk of infecting an entire growing area," Goth says. "Our test can be conducted on individual leaves in a greenhouse or in a lab. The detached-leaf technique is not plant destructive, and leaves from the same plant can be used to test for other pathogens."

Unlike field testing, this method is not weather-dependent and can be done at the convenience of the plant breeder or researcher.

Potato growers worldwide anxiously seek some relief from this seemingly invincible foe. "Having resistant breeding selections and a way to test disease susceptibility are a start," Goth says. [For an earlier story on late blight, see "What Was Around Comes Around," *Agricultural Research*, May 1994, pp. 4-7.]—By **Doris Stanley,** ARS.

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SCOTT BAUER (K5456-7)

ARS plant geneticist Kathleen Haynes and plant pathologist Robert Goth have released two potato breeding selections that resist the most virulent strains of late blight.

Can you name America's No. 1 fresh vegetable on a pounds-per-person basis? Answer below.

- ❏ Onions
- ❏ Carrots
- ❏ Lettuce
- ❏ Potatoes

Per capita consumption of fresh potatoes was over 50 pounds in 1994, compared with 27 pounds of lettuce, 16 of onions, and 8 of carrots. Source: USDA/Economic Research Service

Hybrid Potatoes Survive Blight

Combining the genes of a wild Mexican potato species with those of U.S. commercial potatoes can provide a measure of resistance to the devastation caused by late blight, says John P. Helgeson. He is a plant physiologist in the ARS Plant Disease Resistance Research Unit at Madison, Wisconsin.

Using a genetic engineering technique whereby leaf cells of different potato species are fused together, Helgeson showed that the wild potato, *Solanum bulbocastanum*, could be crossed with commercially grown potatoes.

The so-called somatic hybrids that were produced proved highly resistant when exposed to the late blight fungus in test plots in Wisconsin in 1994. Then, in 1995, they were planted in Idaho, Maine, New York, North Dakota, Washington, West Virginia, and Mexico. In 1996, the clinching test was done in a Wisconsin field where the plants grew well, even without fungicide spraying. The best line, called J103K7, yielded more than 20 tons per acre.

ARS researchers at Beltsville and Aberdeen are now using this line to further develop new varieties.

In Madison, Helgeson and ARS plant geneticists are using a method known as polymerase chain reaction (PCR) to map resistance to late blight in *S. bulbocastanum*. They are using DNA fingerprinting to find pieces of DNA that will allow plant breeders to determine before planting if seedlings are likely to be resistant.

In three different crosses between *S. bulbocastanum* and commercial potatoes, the researchers found a piece of DNA and used it to identify resistance with 95 percent accuracy. This accomplishment should greatly speed development of new resistant varieties because breeders will be able to determine right away whether or not resistance is present in seedlings.

Helgeson presented information about late blight resistance at the January 1997 North American late blight workshop sponsored by USDA's Cooperative State Research, Education, and Extension Service and ARS in Tucson, Arizona.—By **Linda Cooke,** ARS.

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