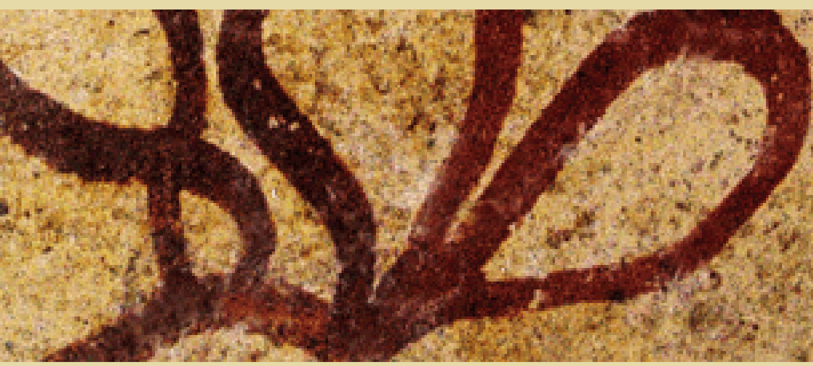
LATE BLIGHT RESEARCH ZEROES IN ON A MOVING TARGET

SCIENTISTS WORLDWIDE HAVE MADE NOTABLE ADVANCES IN COMBATING LATE BLIGHT, THE MOST DAMAGING POTATO DISEASE KNOWN. BUT AS THIS PATHOGEN TRAVELS AROUND THE WORLD AND EVOLVES, RESEARCHERS ARE REALIZING THAT THEY MUST BE AS ADAPTABLE AS THEIR ELUSIVE ENEMY TO KEEP IT AT BAY

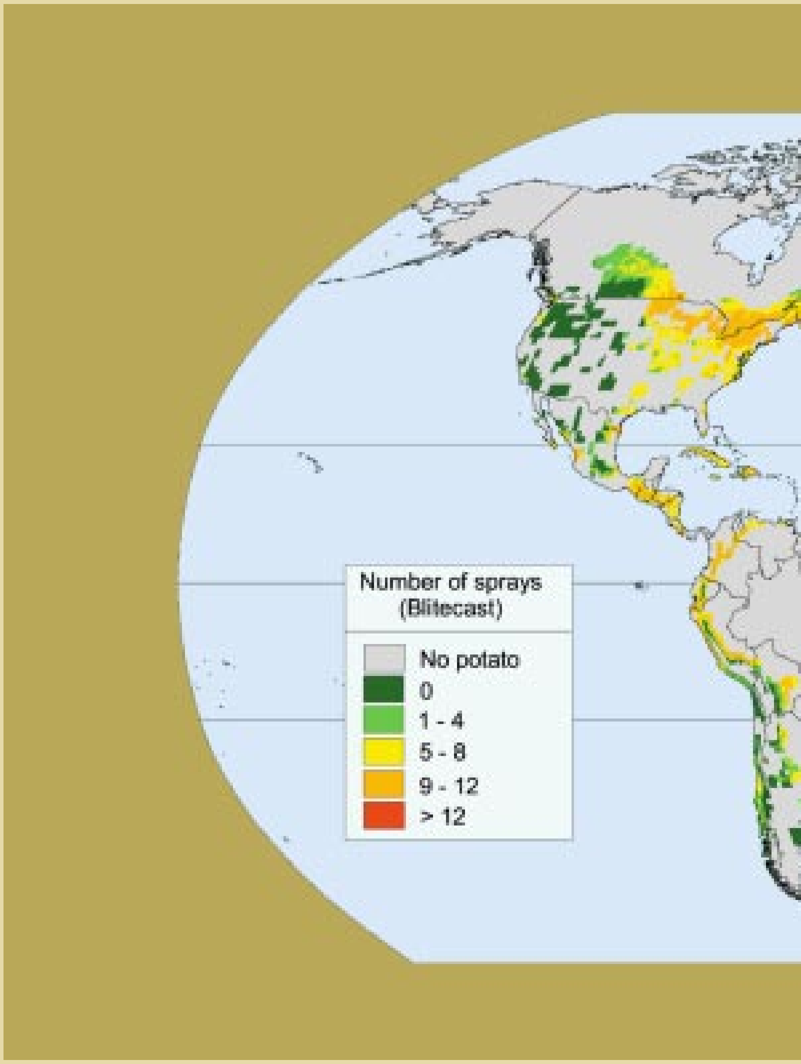


People thought they knew late blight. It has an infamous history as the disease that caused the Irish potato famine, and entire books have been written about it. But recent studies on the biology and population dynamics of *Phytophthora infestans*—the fungus-like organism that causes late blight disease—have demonstrated that the pathogen has far more genetic diversity than previously realized.

"Over the past three or four years we've been finding new forms of *P. infestans*—what scientists call isolates—that have never been seen before," says CIP late blight project leader Greg Forbes. "The pathogen is adapting faster than the control measures used to combat it, and new approaches are urgently needed." The picture is complicated by global warming, which is opening up new opportunities for *P. infestans* in areas where it was previously

not a problem, because low temperatures kept it under control.

Blitecast, a late blight forecasting model, has been linked with geographic information system technology to help researchers estimate potential global severity of the disease (expressed as the number of fungicide sprays required for control).

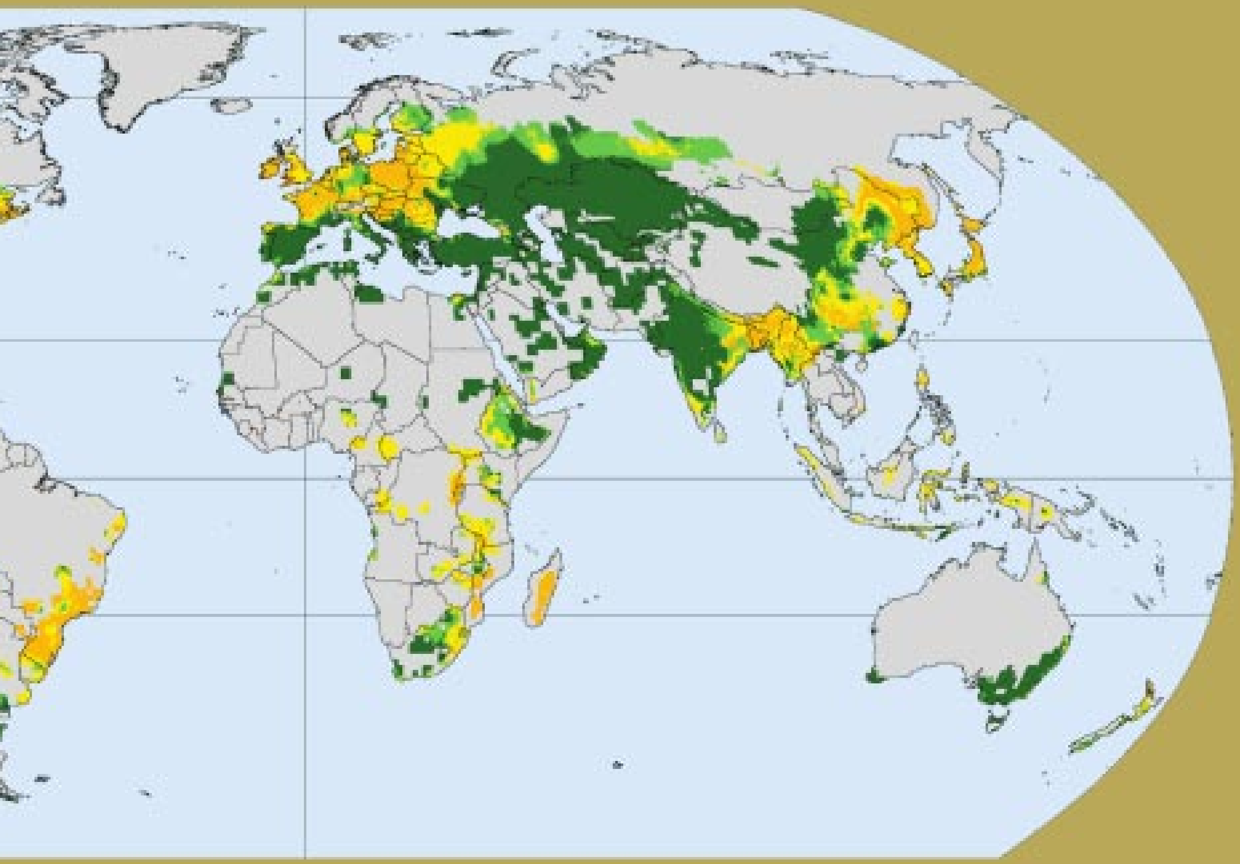


A history lesson

A review of late blight history helps to understand the evolving problem. Part of this pathogen's adaptability results from the fact that it can reproduce either asexually or sexually. To date science has recognized two main "mating types," commonly distinguished as "A1" and "A2." An emerging theory has it that these two types co-evolved with potato's wild relatives among the *Solanum* species—which include wild potatoes, tree tomatoes, pear melons, and numerous weedy species and woody vines—in the Andes. This contrasts with the commonly held view that *P. infestans* originated in the central highlands of Mexico, where it is thought to have "jumped" to cultivated potatoes. "There are many hypotheses about the origins of the pathogen," says Forbes, "and the evidence is still coming in. The fact is that to date, we've generated a lot more questions than answers."

At any rate, pathologists believe that the A1 mating type traveled from Mexico to northeastern USA sometime around 1840. It went on to Europe where, in the late 1840s, it caused one of the greatest famines in human history. The A1 type eventually made its way to Africa, Asia, and back to South America. The vehicle: potatoes being traded and sold to meet worldwide demand. It was not until the 1970s that the A2 mating type reached Europe, probably carried in a shipment of potatoes imported from Mexico to offset the effects of a major drought. From there, history was repeated as this "new" form of the pathogen spread around the world.

When A1 and A2 are present in the same environment they can "recombine" through



sexual reproduction. The result is an explosion of new types of the pathogen, which makes it even more difficult to manage. Almost all potato-growing countries are now affected by the problem. Even so, in North America and Europe farmers are willing to grow highly susceptible potato varieties that fetch good prices on the market, resorting to chemicals to control the disease. But as late bight evolves, these farmers are being forced to use increasingly large amounts of fungicides, and to use them with greater frequency. What’s more, a class of chemicals that used to be considered invincible is losing its effectiveness in the face of the new disease types.

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Late blight approaches a sexual frontier

Working from new data sets and reports of increasing late blight damage in highland areas of the Andes, CIP pathologists believe that the emergence of previously unknown forms of the late blight disease—and its appearance in areas previously unaffected—could have significant consequences for ancient potato varieties and the farmers who grow them. Their concern is focused on the Lake Titicaca region and surrounding areas. This region is thought to be the potato's genetic center of origin, a theory borne out by the significant diversity of potatoes found there.

"What we are seeing is the convergence of two mating types, one moving south from Colombia and Ecuador, and the other coming up through Bolivia from Brazil," says CIP pathologist and late blight project leader Greg Forbes. "Our fear is that farmers in the high Andes—the people who have served as the traditional custodians of potato biodiversity—may lose native varieties that have been grown for many centuries, and thereby their means of survival." Local consumers hold these potatoes in high esteem. Not only are their varied tastes, textures, and colors a source of culinary diversity, native potatoes are also important in traditional culture and are often used in ceremonies or as gifts.

Maria Scurrah, a CIP adjunct scientist who has spent years working with farmers in the high Andes, can testify that this is no longer just a theoretical problem. "Late blight is encroaching on areas that were rarely affected by it in the past. Essentially, the pathogen is moving up the mountainside, showing up in places where farmers have hardly ever encountered it."

Biodiversity fights back

"Traditional varieties are not going to disappear because of late blight," says CIP potato breeder Juan Landeo, "but it's likely that they will be under greater pressure than in the past." Landeo bred one of Peru's most popular and widely grown potatoes, known as Canchan. Depended on for years as a late-blight-resistant variety, Canchan's ability to withstand the disease has, in recent years, broken down. To help farmers cope, Landeo has developed a new series of blight-resistant potatoes, suitable for production under extreme highland conditions.

The new "populations", now ready for selection and release, were derived from materials of the *andigena* subspecies collection held in CIP's genetic resources complex in Lima. The genebank safeguards about 85 percent of all known native potato varieties, including 15,000 farmer-selected andigena potatoes collected in nine countries during the 1970s and 1980s. The CIP genebank collections, which also include sweetpotato and other Andean roots and tubers, are protected under an agreement with the UN Food and Agriculture Organization that charges the Center with conserving genetic resources so as to make them available equitably and without restriction. CIP uses these materials, for instance, to help preserve the diversity of native varieties in the Andes through restoration programs (see *Next steps for Chayabamba,* page 43).

Bred over a 12-year period using conventional plant breeding techniques, the new andigena plant types carry multiple late blight resistance genes, which should help them compete against many forms of the disease. Most native Andean varieties belong to the subspecies *andigena*, but generally lack such resistance. For this reason, the search for the resistance traits incorporated in the new varieties involved a long and careful process of screening and selection. The new materials have some added advantages: they produce higher yields than conventional varieties in less time, a characteristic that should reduce their exposure to the disease in farmers' fields, while offering most of the eating and market characteristics valued by highland farmers.

"What we've tried to do is breed a highland-type potato that has most of the qualities that will make it acceptable to processors and allow it to compete in urban markets," Landeo says. It is Landeo's hope that these new andigena potatoes, now being distributed in the Andes through farmer field schools, will eventually enable people in Africa and Asia to enjoy the special taste and texture of native Andean potatoes. Because of their unique features, they are much better prepared to adapt to areas outside of their Andean home than their native relatives.

Late blight symptoms on tubers (below). At 3,500 masl, Huanuco, Peru, serves as a good testing ground for late-blight-resistant varieties and management practices (following page).

An expanding portfolio

The situation is even more complex in the potato-growing areas of the developing world, where seasons, day-length regimes, altitudes, and socio-economic and agro-ecological conditions are diverse, especially compared with those found in industrialized countries. "The solutions used in the northern hemisphere just don't work here," says Pamela Anderson, CIP's Deputy Director General for Research. "CIP has the mandate for late blight research in the tropics, and one of our main goals is to reduce farmer dependence on chemicals. This makes the replacement of susceptible varieties with more resistant ones a pivotal point of our late blight control programs."

CIP scientists are concerned that late blight is "moving up the mountainside," becoming a serious threat in places where it was rarely encountered in the past.

More than 20 developing countries—including major potato producers such as China, Peru, and Kenya—are in the process of releasing the latest lines of late-blight-resistant potatoes produced by CIP plant breeders in Lima (see *Late blight in China: A cause for concern,* page 47). Unlike early late-blight-resistant populations, these new potatoes carry multiple resistance genes to help them survive under high, and varied, disease pressure. But breeding is not a one-time fix, and there is no miracle potato. Disease resistance must not only be matched with local requirements and preferences, it must also be continually improved to keep up with and withstand the evolving forms of the disease (see *Late blight approaches a sexual frontier,* page 38).

In a similar manner, resistant potatoes cannot do the job alone. Fungicides are still needed, but they need to be used rationally to protect the environment, human health, and the investments of resource-poor farmers. A recent study in developing countries revealed that the number of fungicide sprays used to control the disease is often far more dependent on purchasing power than it is on best practice recommendations. At the same time, farmers' decisions to use resistant

varieties may be overturned by local consumer preferences or by market considerations that affect the supply of high quality seed.

CIP scientists have made headway by developing and adapting integrated control programs using the farmer field school methodology. In these programs, variety introduction is balanced with discovery learning to increase farmers' understanding of control options that will enable them to use chemicals sparingly while protecting profits and productivity. Field schools have not only helped speed up location-specific selection and introduction of new varieties, farmer input has also contributed to reorienting ongoing breeding research.

Modeling research has also been integrated into CIP's late blight portfolio. For instance, tradeoff modeling is helping farmers to visualize how they can make better decisions about optimum use of pesticides and avoid unnecessary health risks (see CIP's Annual Report 2001). At the same time, disease forecast models are increasing researchers' understanding of relative late blight severity in the diverse agro-ecological areas of the developing world, where information of this sort is scarce. The data will serve as a guide for allocation of resources to the areas where they can make the biggest difference in production, food security, and poverty alleviation.

Recombining research

"We are just beginning to scratch the surface," says Forbes. "We need to move quickly because the picture is changing rapidly and there are new variables, like climate change, that need to be

factored in. Basically, we need to expect the unexpected. Innovative kinds of research—like modeling and pathogen studies—will help. The question is, how can we do it with the resources now at our disposal?"

Partnership will help to achieve some of these objectives. Simulations of management tactics and scenarios are being conducted, for example, through strategic alliances with researchers at Israel's Volcani Institute, the Brazilian Agriculture Research Corporation (EMBRAPA), Plant Research International in the Netherlands and the USA's Cornell University. The models, which allow scientists to process huge amounts of information, are helping researchers visualize how variables such as climate, socio-economic conditions, and local preferences can make or break a control strategy. The Global Initiative on Late Blight (GILB), a worldwide network of researchers, technology developers, and agricultural knowledge agents, lends communication and information support to these initiatives.

At the core of the problem, nonetheless, is the understanding of the elusive *Phytophthora infestans* pathogen and the way it reproduces and interacts with its host, and the fact that this information is still incomplete. Continued studies in population dynamics are fundamental if

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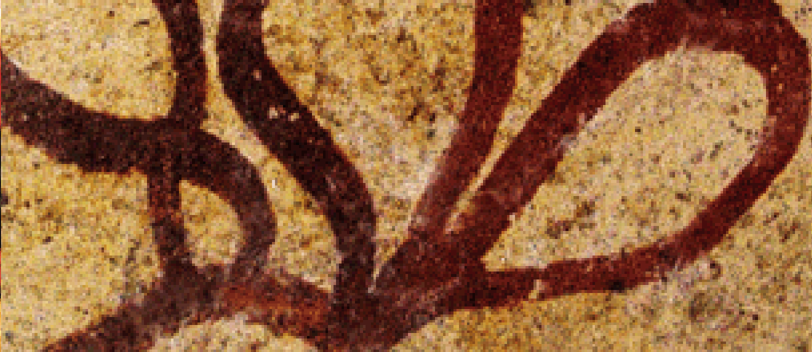

NEXT STEPS FOR CHAYABAMBA

The potato farmers of Chayabamba, an Andean community some 300 kilometers east of the old Inca capital of Cusco and more than 4,000 meters above sea level, are facing a period of consider-able uncertainty. Late blight not only cost them last year's potato harvest, it also devastated the stores of planting materials needed to sow next year's crop.

As a coping strategy, Chayabamba farmers would normally try to borrow seed from nearby communities, but neighboring farmers may have also suffered losses and have little seed to spare. A second possibility would be to purchase seed on the open market. Commercial seed suppliers, however, are unlikely to have the varieties that farmers need and want, and there are few guarantees that purchased seed will meet adequate quality standards.

The CIP genebank is poised to help by providing local communities with "starter seed" for their rebuilding programs. "One of the principal functions of a genebank is to guarantee that traditional varieties survive. When disaster strikes, as it did last year in Chayabamba, we are there to help," says Willy Roca, head of CIP's genetic conservation project.

Seed return programs are not just the right thing to do, Roca adds, they are also the smart thing to do. "We not only provide planting material, we also work with local NGOs and community groups to multiply seed at locations close to where it will be needed."

Future restoration efforts will be aided by the development of community field genebanks, closely linked to the CIP collections, in strategic microcenters of genetic diversity. According to Roca, "Traditional brick and mortar genebanks with their cold storage rooms are a last line of defense. If you want to maintain genetic diversity and encourage evolution, your best option is help farmers grow traditional varieties in the fields where they first evolved, rather than in test plots at an experiment station."

scientists are to fill the gap. Forbes notes, however, that it will take at least three years of additional research and more than US$1 million to fully understand the dynamics of the late blight pathogen in the Andes alone. Special project funding for population studies has thus far been provided by the Netherlands Ministry of Agriculture, Nature Management and Fisheries (LNV), the Swiss Agency for Development Cooperation (SDC), and the United States Agency for International Development (USAID).

"Late blight is CIP's biggest challenge," says Pamela Anderson. "It is also our biggest opportunity. It gives us a chance to show how all that we are doing—in conservation, characterization, and breeding; integrated crop management and systems analysis; and partnerships for development—can fit together to make a difference in people's lives and livelihoods."