CIP SCIENTISTS SET TO BREACH AGE-OLD DISEASE BARRIER

IN WHAT APPEARS TO BE A MAJOR ADVANCE IN THE FIGHT AGAINST BACTERIAL WILT DISEASE, CIP PATHOLOGISTS REPORTED IN 2003 THE LIKELIHOOD THAT HIGH LEVELS OF DISEASE RESISTANCE CAN BE FOUND IN A SMALL GROUP OF WILD POTATO SPECIES

The identification of a potential source of resistance to bacterial wilt builds on more than 30 years of genetic conservation and plant pathology research, representing an important piece in a puzzle that has escaped solution by generations of scientists and the farmers that they serve.

Bacterial wilt, which is second only to late blight in its impact on developing country potato production, affects millions of farm families in more than 40 developing countries. "The disease is not just a production problem; it has a profound effect on the environment and on poverty," says CIP Director General Hubert Zandstra. "By providing farmers with new technological options, anchored by resistant varieties, we hope to create a platform that will benefit not only producers, but society at large."

The search to identify sources of resistance, Zandstra notes, was given new impetus in the late 1990s by the development of a highly accurate screening technique that allows researchers to detect latent forms of the disease. Armed with the new procedure, CIP plant pathologists spent nearly three years screening thousands of wild and cultivated plants for resistance. "We have good indications that their search was successful and that resistance will be confirmed in a third and final screening to be conducted during the second half of 2004," Zandstra says.

In Huanuco, Peru, farmers participating in field schools have learned to diagnose bacterial wilt accurately and to use control measures—such as removing wilted plants and spreading ash or chalk in their place—that help them to prevent disease dissemination in their fields.

Many of the wild species screened in 2003 for bacterial wilt resistance were first observed by CIP Plant Taxonomist Alberto Salas growing in locations where potato farmers experience severe losses from the disease. "Salas' observations," says plant pathologist Sylvie Priou, "provided the first indication that resistance might exist in nature."

The pathogen that causes bacterial wilt, *Ralstonia solanacearum*, is spread principally through infected seed stocks. Because disease symptoms are invisible in cool climates, where most potato seed is produced, even seed tubers that appear to be healthy can carry the disease pathogen. To control bacterial wilt, farmers have only two options: to purchase costly certified seed, or to eliminate the pathogen in their fields using crop rotations and other sanitation measures.

In 2000, CIP economists estimated that the availability of a potato with bacterial wilt resistance would increase productivity an average of 10 percent across the developing world. Overall benefits were calculated at US$125 million per year, with the greatest impact in countries such as China, Bangladesh, Bolivia, and Uganda.

Hope from the wild

To come up with these promising results, CIP scientists subjected more than 3,900 genotypes of potatoes from 111 wild species and subspecies to two series of greenhouse tests. The plants were exposed to a mixture of aggressive disease variants in a simulated tropical environment that combined high temperatures and humidity.

A third series of tests will screen for the presence of the pathogen in its latent form in tubers derived from inoculated plants. The tests, which are believed to be the first of their kind to be conducted, will help to identify resistance in both the plant and its tubers.

In the first series of tests, resistance to all variants of the pathogen was identified in four genotypes from the species *Solanum acaule*. The search for additional sources of resistance will continue, however, throughout 2004 as six promising, but rare wild species become available for testing.

Officials at the Conservation, Food, and Health Foundation (CFH), a US Philanthropy that provided funding for the research, note that CIP's bacterial

wilt project demonstrates how private philanthropy can set the stage for important scientific partnerships.

"Our expectation was that by investing in the research we could stimulate larger contributions by public sector donors, who would become interested once Center scientists had demonstrated that resistance did indeed exist in nature," explains Prentice Zinn, a CFH project officer. "Now that the research is close to completion, we hope that they will support the next phase of trials." Two other philanthropies, the Wallace Genetic Foundation and the International Foundation, also provided funding for the project.

Sylvie Priou, who heads up CIP's bacterial wilt research team, notes that because the sources of resistance identified thus far are derived from wild relatives of the domesticated potato, it should be relatively straightforward to move resistance genes into commercial potatoes, either through conventional breeding or genetic transformation. "The end product would essentially be the same," she says, "but a breeding program that uses non-adapted wild germplasm could take 15 to 20 years, while direct gene transfer might produce equivalent results in about half the time."

Multiple strategies

Meanwhile, CIP scientists continue to work on and disseminate other control strategies, including moderately resistant varieties, pathogen detection, biological control, and management practices that help farmers eliminate the pathogen from their fields.

"Right now the most effective way to prevent bacterial wilt," Priou says, "is to detect the pathogen on seed before it reaches farmers' fields."

Industrialized countries, which also suffer from bacterial wilt, routinely screen large amounts of seed tubers using sophisticated detection techniques that are effective, but expensive. The CIP-developed detection kits are equally sensitive and are far more appropriate to developing country conditions. At a cost of approximately US$100, each kit can be used to evaluate up to 300 tons of tubers, enough seed to plant 150 to 200 hectares. CIP has also developed ultra-sensitive kits that allow researchers to detect very low populations of the pathogen in the soil.

There is one drawback: CIP's kits, now in use in 13 countries, can only reduce seed infection rates if used in conjunction with an organized seed system. Such systems, which eliminate infected seed before it reaches farmers fields, unfortunately, are rare in developing countries.

While CIP continues to lend support for seed system development in its partner countries, the Center is backing farmers up by providing immediate, albeit limited, defense against bacterial wilt in the form of a new series of 15 disease-tolerant potatoes, which will begin shipping in 2004.

To achieve sustainable yields using the tolerant varieties, farmers will need to periodically renew their supplies of disease-free seed and use measures—such as crop rotation—to eliminate the pathogen from their soils.

Although rotational systems are an ancient Andean tradition, in recent times crop rotations have been severely reduced because of the pressure on the land resulting from population growth. Abandoning potato production for the four to five years needed to deprive the bacterial wilt pathogen of its food source is an unattractive option, especially if one takes into account the importance of this crop for the burgeoning Andean population. New cultural practices and control components developed by farmer-researcher groups in Peru and Bolivia are changing this picture. With funding from the United Kingdom's Department for International Development (DFID), researchers have identified simple rotations that will allow farmers to sanitize their soil while planting potatoes more frequently.

A recent example came from Peruvian and Bolivian participants in farmer field schools. Working in highly infested fields, they succeeded in sanitizing their soils by following potatoes with two successive crops of cabbage, onions, sweetpotatoes, or arracacha. (Arracacha, an Andean root crop, is a relative of carrot and is frequently used to produce high quality baby food or as a starchy dessert.) The experiment was so successful that the farmers were replanting potatoes within 18 months. The results of the trials were subsequently confirmed using CIP-developed testing kits.

These hands-on solutions should help farmers to keep bacterial wilt at bay. Priou notes that researchers continue to search for other crops with good market potential that can be used to further reduce rotation times while increasing family incomes, thereby ensuring greater food security for people living in marginal environments. Combined with other common-sense management practices, such as removing volunteer potato plants and weeds, the techniques provide farmers an affordable way of coping with a difficult problem.

Spreading the word

"Our bacterial wilt management program is not sophisticated science, but it is practical and can

Sylvie Priou and Alberto Salas examine potato plants in a CIP greenhouse.

Biocontrol of bacterial wilt

In laboratory and greenhouse tests conducted in 2003, CIP scientists identified several naturally occurring bio-agents that appear to prevent the bacterial wilt pathogen from attacking tomato, a relative of potato that is extremely susceptible to the disease. The control agents include the bacteria *Pseudomonas putida* and *Burkholderia cepacia,* both of which significantly diminished disease symptoms and reduced latent infection. The results, while highly promising, require additional study and experimentation. First the bacteria must be proven effective with potatoes. Then researchers will have to test their effectiveness in farmers' fields, and ensure that they are economically viable and easy to use.

make a difference to poor people who depend on potatoes for food and income," Priou says. She notes that participating farmers are eager to adopt the new methods and that many of the participants are now teaching people in neighboring communities to use them.

"It's not uncommon for highland farmers to share their expertise. It's part of their tradition, but it also makes sense. What happens in one community affects those who live nearby. The pathogen that causes bacterial wilt can easily spread from field to field on farmers' shoes and tools, or even in irrigation water," she says.

Farmer field schools, based on discovery learning, are ideal vehicles for spreading these innovations. "The field school concept helps farmers to understand the entire disease and crop production cycle and unravel large parts of a complicated puzzle. Once they understand what's going on, they're usually willing to adopt various management options and to experiment with new ones," Priou says. Among these are seemingly unusual practices such as sanitizing the soil at planting time by applying bleach, chalk, disease-free barnyard manure, or even ashes from cooking fires.

"Most importantly," she adds, "we researchers are learning how to leverage farmers' knowledge not only so it helps others, but so that it provides feedback on the relevance of our research." Priou notes that a number of studies to confirm the effectiveness of traditional farmer methods for controlling the disease are currently underway.

CIP's bacterial wilt farmer field school project was conducted in partnership with national programs in Bolivia and Peru; and with community development groups, nongovernmental organizations, national crop protection agencies, and PROINPA, a private research and development foundation in Bolivia. Lessons learned from the initiative are currently being compiled in a user-friendly field guide and should be available before the end of 2004.