

Breakthrough in bacterial wilt resistance

“It’s true,” says CIP plant pathologist Sylvie Priou. “We have found that seven genotypes from two wild Andean potato species have high levels of resistance to wilt and tuber infection.”

This is the first real proof of bacterial wilt resistance in nature. And since the

resistance comes from a wild relative of the domesticated potato

its transfer to commercial varieties

resistance comes from a wild relative of the domesticated potato its transfer to commercial varieties should not be too difficult – whether by conventional breeding procedures or by direct gene transfer.

Major constraint

Bacterial wilt is the number two constraint (after late blight) on potato production in more than 40 developing countries. More than four million hectares are infected, causing damage estimated to exceed US\$1 billion annually. Tens of millions of farm families are affected, suffering yield reductions that can amount to total loss. To have found a source of resistance to this scourge is a major breakthrough that ultimately could increase productivity by an average of 10% across the developing world and by substantially more in the most severely afflicted regions.

Priou and her team at CIP have spent four years on a large-scale screening effort. 4461 genotypes from 113 wild species and

subspecies of potato were tested for resistance. In first-of-their-kind tests conducted during 2004, genotypes that showed resistance were re-exposed to the pathogen in less severe conditions, to assess the presence of latent infection in tubers. Seven wild potato genotypes came through very successfully, exhibiting high levels of resistance to both wilt in the stems of mature plants and latent infection in the tubers. Studies to identify the mechanisms and genetic basis of the resistance will proceed during 2005, before the trait is transferred to commercial potatoes – and thence to the fields of farmers in developing countries. “I’m 90% certain that our final tests will confirm the resistance we have already seen,” says Priou. “Just a few more months ...”

Priou’s reluctance to make a definitive announcement at this stage reflects both scientific caution and her respect for a tough and resourceful adversary. *Ralstonia solanacearum*, the bacterium

that causes bacterial wilt (see Box p3), has been outwitting farmers and scientists for a very long time. For developed nations, keeping the disease at bay is essential and, fortunately, affordable. The same cannot be said of developing nations, and it is here that the work of Sylvie Priou and her team at CIP is especially relevant.

Supersensitive methodology

An important milestone in the battle against bacterial wilt was passed in the late 1990s, with the development at CIP of a procedure that vastly enhanced available methods of detecting *Ralstonia solanacearum* in its latent form. Priou and the CIP team refined the procedure, which multiplies the bacteria in samples to be tested with the NCM-ELISA technique (enzyme-linked immunosorbent assay on nitro-cellulose membrane). It is one million times more sensitive than methods previously used to detect latent infection in potato

Wild species growing in CIP's screenhouses

CIP ARCHIVES



A healthy *Solanum chacoense* in the laboratory

CIP ARCHIVES

Solanum acaule in its native habitat

CIP ARCHIVES



tubers. The procedure is as sensitive as the sophisticated techniques used in developed countries – but simpler, and far cheaper.

“The most effective way to prevent bacterial wilt is to detect the pathogen on seed before it reaches the farmers’ fields,” says Priou. “Seed taken from infected fields

often carries latent infection, even if it comes from healthy-looking plants.” CIP distributes detection kits at a cost of US\$120 each that allow users to evaluate up to 250 tonnes of tubers, enough seed to plant 150 to 200 hectares. They are already in use in more than a dozen countries, doing good work.

But while certification, containment and good farming practices ease some of the damage caused by bacterial wilt, no one doubts that the availability of resistant varieties would achieve more. With no susceptible potatoes to feed on, *Ralstonia solanacearum*

would fade out on even the most heavily infested soils.

Although CIP's plant breeders had been working on the development of a resistant variety for about 15 years, the prize had eluded them. The vastly more sensitive NCM-ELISA procedures re-invigorated the search. Since it is so sensitive, scientists can be confident that if no traces are found then the samples are free of the pathogen. But first, were any wild species resistant to bacterial wilt in even its visible form?

Resistance exists in nature

CIP is the custodian of the world's largest collection of potato germplasm, so there were several thousand genotypes from 199 wild

species and subspecies of potato that could ultimately be tested, but CIP's plant taxonomist Alberto Salas was able to give the team a clue as to which might be resistant. "I was on an expedition collecting wild species up to about 3,800 m in the Porcon area of Cajamarca," he recalls. "It was in the 1970s. We were not looking for resistance in particular, just any wild potato species, but close to where I had found a few healthy specimens of wild *Solanum acaule*, I noticed a field of cultivated potatoes that was badly infected with bacterial wilt." Within this general gene pool were also 30 newly acquired wild species that had never been tested. "Alberto Salas'

observations gave us the first indication that resistance to bacterial wilt might exist in nature," says Priou.

After four years of intensive screening, CIP's team has found 49 genotypes of 11 species resistant to at least five strains of the pathogen. The most virulent forms of the pathogen found in different parts of Latin America were used to infect the wild potatoes to test the durability of their resistance. After having challenged 28 of the 49 selected genotypes in less severe conditions that allowed the plants to produce tubers, six genotypes of the wild species Alberto Salas saw that day – plus one genotype of another wild species, *Solanum chacoense* – showed high levels of resistance to both wilt and tuber infection. But there are still 21 selected genotypes of five other species to be tested for tuber infection – they could greatly broaden the genetic basis of resistance.

As the likelihood of confirming wilt resistance in

"Alberto Salas's observations gave us the first indication that resistance to bacterial wilt might exist in nature"



Completely destroys the potato tuber Bacterial wilt also

CIP ARCHIVES

wild species became a reality, Priou and her team broadened their investigations: was there bacterial wilt resistance among genotypes known to have some resistance to another disease: late blight? Results so far are promising. "During the current project period, we have tested 177 of the genotypes that CIP's late blight team previously found to have some level of resistance," Priou explains. "And among these the selection rate of wilt-resistant genotypes reached 18.6%, compared with only 3.3% for other material tested."

Late blight and bacterial wilt together cause widespread hardship and cost farmers world-wide over US\$1.5 billion in control costs and lost harvests. "If combined resistance to both diseases can be confirmed, it would represent an important advance," Priou notes, with commendable understatement.

Box3 An expensive disease

Ralstonia solanacearum, the bacterium that causes bacterial wilt, can survive in small numbers in even the worst circumstances, and then proliferate rapidly when conditions allow. Low concentrations are enough to sustain a viable population in the soil, and a potato planted in such ground will very quickly become infected. As the plant grows its vascular system becomes clogged with the rapidly multiplying bacteria. The plant wilts and dies; the bacteria retreat to the tubers, there either to concentrate as a pus-like mess in the vascular ring that causes the tuber to rot, or to adopt its latent state.

The latent state of *Ralstonia solanacearum* is the most difficult. The bacteria are invisible to all but specialized testing. The tubers appear healthy, but will spread the disease wherever they are planted. They can be eaten, since mammals are immune to the organism and its latent form does not affect the taste or nutritional value of the tubers. This may seem a blessing, but the bacteria can survive a journey through the digestive system. Even sewage treatment plants do them no harm, and when they reach water, aquatic plants serve as staging posts for further proliferation as they disperse via irrigation systems and back onto the land.

Ralstonia solanacearum originated in Mexico and the Andes, where it co-evolved with the potato. Europe was invaded by virulent strains of *Ralstonia* in the 1990s. Now all of Europe maintains a rigorous system of quarantine, testing and certification. More recently, its arrival in the United States was an immediate and serious threat to the huge US potato industry.

Containing the outbreaks of bacterial wilt in Europe and the United States cost millions and maintaining a quarantine on the disease is a massive recurrent expense – but there is a lot at stake. A huge industry, supplies of a staple food and many livelihoods depend upon the continuing viability of potato production. And in developing countries it is often a matter of life and death.