

## **Ptr1: a case study of convergent evolution of AvrRpt2 recognition in diverse solanaceous species**

Carolina Mazo-Molina, Ph.D.  
Boyce Thompson Institute for Plant Research, Ithaca, NY, USA  
Cornell University, Ithaca, NY, USA

Race 1 strains of *Pseudomonas syringae* pv. tomato (*Pst*), which cause bacterial speck disease of tomato, are becoming increasingly common and no simply-inherited genetic resistance to such strains is known. We discovered that a locus in *Solanum lycopersicoides*, termed *Pseudomonas tomato race 1 (Ptr1)*, confers resistance to race 1 *Pst* strains by recognizing the type III effector AvrRpt2. In Arabidopsis and apple, strains of *Pst* and *Erwinia amylovora* expressing AvrRpt2 degrade the RIN4 protein thereby activating *RPS2* or *Mr5*-mediated immunity, respectively. *Ptr1* also recognized homologs of AvrRpt2 from diverse bacteria including *Ralstonia pseudosolanacearum* strains expressing RipBN, and this correlated with the ability of AvrRpt2 homologs to degrade RIN4. Using site-directed mutagenesis of AvrRpt2 we found that, like *RPS2*, activation of *Ptr1* requires AvrRpt2 proteolytic activity. The identification of the *Ptr1* candidates from a pool of segregating F2 plants for the *Ptr1* locus followed by the analysis of gene models in the *S. lycopersicoides* genome sequence and RNA-Seq data led to two nucleotide-binding leucine-rich repeat protein (NLR)-encoding genes as the strongest candidates for *Ptr1*. One of these two candidates was found to encode *Ptr1* based on its ability to mediate recognition of AvrRpt2 and RipBN when it was transiently expressed with these effectors in leaves of *Nicotiana glutinosa*. The ortholog of *Ptr1* in tomato and in *Solanum pennellii* is a pseudogene. However, a functional *Ptr1* ortholog exists in *Nicotiana benthamiana* and potato, and both mediate recognition of AvrRpt2 and RipBN. In apple and Arabidopsis, recognition of AvrRpt2 is mediated by the *Mr5* and *RPS2* proteins, respectively. Phylogenetic analysis places *Ptr1* in a distinct clade compared with *Mr5* and *RPS2*, and it therefore appears to have arisen by convergent evolution for recognition of AvrRpt2. *Ptr1* could play an important role in controlling bacterial speck disease, and its cloning is an example of convergent evolution for recognition of a widespread type III effector.