Exploiting the Phytophthora infestans genome to determine targets for sustainable potato protection

I. HEIN(1), E. M. Gilroy(1), S. C. Whisson (1), Z. Tian (1), L. Pritchard (1), G. Bryan (1), P. R. J Birch(2)
(1) Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, UK
(2) Division of Plant Sciences, College of Life Sciences, University of Dundee at SCR, Invergowrie, Dundee DD2 5DA, UK

Introduction: Phytophthora infestans, the causal agent of late blight disease remains, more than 160 years after instigating the Irish famine, the most devastating pathogen of potato. Breeding resistant potato cultivars is often undertaken by rapidly occurring pathogen variants to overcome resistance (R) genes and quantitative field resistance. R gene-mediated resistance is manifested by the recognition of pathogen-derived effectors. Exploiting the recently sequenced P. infestans genome provides a unique opportunity to identify targets for potentially more durable resistance. Our strategy relies on the identification of secreted, invariant and functionally essential (and thus non-redundant) effectors that, as the pathogens ‘Achilles heel’, yield resistance that is more durable by pathogen variants (Figure 1).

Results: Expression of effectors in collections of cultivated and wild Solanum species maintained within the Commonwealth Potato Collection (CPC) have identified sources of R genes that recognise specific effectors, including AVR2, recognised by the R2 resistance gene which maps to the more durable resistance locus present in cultivar Shiring & Lady Balfour (Figure 2) and Avr3a. Avr3a, the first effector characterised from P. infestans, exists in two forms: AVR3aK80I103, which is recognised by the cognate potato gene R3a and AVR3aE80M103 that evades recognition by R3a. Transient and stable silencing of 25 effectors in P. infestans has identified 15 that are functionally essential and include Avr3a (Figure 4). Interestingly, the observed loss of pathogenicity in Avr3a-silenced P. infestans lines can be restored by transient expression of both Avr3a alleles (Figure 5). Studying allelic variation of Avr3a in 82 diverse Mexican P. infestans isolates revealed that 77 contain Avr3aK80I103. Furthermore, CPC accessions from Mexico including Solanum demissum, S. semidemissum, S. stoloniferum, and S. stoloniferum EM KI have identified 15 that are functionally non-redundant effectors that are essential for pathogenicity. Introgression of genes from wild potato accessions that recognise such effectors could mark the way towards more durable resistance for potato cultivars.

Conclusions: Effector silencing and in planta complementation as shown for Avr3a, demonstrates that P. infestans, unlike some pathogenic bacteria, potentially contains functionally non-redundant effectors that are essential for pathogenicity. Introgression of genes from wild potato accessions that recognises such effectors could mark the way towards more durable resistance for potato cultivars.