University of Worcester

Title: Investigating PAMP/DAMP triggered immunity during Arabidopsis-Hyaloperonospora interactions

Closing date: Fri 23rd March 2012

Interview date: Weds 25th April 2012

Supervisors

Director of Studies: Dr Mahmut Tör, National Pollen and Aerobiology Research Unit, Institute of Science and the Environment, University of Worcester, UK.

Other Supervisors:

Dr Cyril Zipfel, The Sainsbury Laboratory, Norwich Research Park, Norwich, UK.

Dr Lee Byrne, Institute of Science and the Environment, University of Worcester, UK

Context

A wide spectrum of parasites including viruses, bacteria, fungi and nematodes exploit plants as a source of food and shelter. During the infection process, these would-be pathogens are usually recognised by the defence system of the plant. Disease resistance genes recognising elicitors originating from pathogens often activate defence. Successful recognition of these molecules leads to the generation of an oxidative burst; production of superoxide (O2-), hydrogen peroxide (H2O2), hydroxyl radical (OH-), hypohalite (e.g. OC1-), and nitric oxide (NO-), collectively known as reactive oxygen species (ROS). Generation of these molecules alters the redox (reduction-oxidation) state inside and outside the cell. Such alterations can disrupt cellular membranes, induce oxidative changes in DNA or DNA precursors, damage sulphate bonds of proteins and modify cellular metabolism. In addition, they regulate signalling networks and their biological function impinges on a variety of key physiological processes.

These events subsequently lead to the restriction of pathogen growth. Traditionally, plant breeders have used R-genes in their breeding programmes, providing the growers with new varieties. However, this approach relies on a single gene product in a plant recognizing a single product from a pathogen. The major drawback of this system is that the pathogen easily overcomes this type of resistance by modifying the recognized molecule (well known as boom and bust cycle), and the search for a new resistance source by the breeder carries on. Recent studies showed that pathogens also have conserved elicitors (known as pathogen associated molecular patterns-PAMPS), which trigger a broad-spectrum defence response. In addition, pathogen induced ROS production generates endogenous elicitors from the host (damage associated molecular patterns-DAMPs), which also trigger further defence responses

PAMPs were originally described as microbial elicitors and could be present in pathogenic and non-pathogenic micro-organisms. They are unique to microbes, invariant among the given class of micro-organisms and seen as foreign molecules by plants. They are important for microbial fitness and are able to elicit innate immune responses in a non-cultivar specific manner. Their conserved nature makes it difficult for the pathogen to avoid recognition through adaptive evolution of these molecules. Several PAMPs including flagellin, and Ef-Tu, chitin and Pep13 have been identified from bacterial, fungal and oomycete pathogens, respectively (Tör, 2008; Zipfel, 2009).

Mechanical injury, insect or herbivore damage releases specific signals, which have been known as wound-induced proteins in plants. However, these molecules are also released during programmed cell death (PCD), hypersensitive reaction (HR), or trailing necrosis. The term ‘damage-associated molecular pattern molecules (DAMPs)’ are currently used to describe these molecules (Lotze et al, 2007; Tör et al, 2009). DAMPs are generated at the damage site and signals arising from them are delivered to other undamaged parts of the plant in a systemic manner.

Plants have a highly evolved surveillance system to detect a broad range of signals originating from pathogens, damaged tissues, or altered developmental processes and can initiate sophisticated molecular mechanisms that result in defence, wound healing and development.

Receptor-like kinases (RLKs) or receptor like proteins (RLPs) are membrane-bound signalling molecules with an extracellular ligand-binding domain. They recognize certain patterns in external and internal signals (hence they are known as Pattern Recognition Receptors, PRRs) and provide an early warning system for the presence of potential pathogens by activating protective immune signalling in plants. Both PAMPs and DAMPs are recognized by these PRRs. There are around 600 of these PRRs in Arabidopsis and mutant lines for each exist. NPARU and The Sainsbury Laboratory hold the entire collection of these mutants, thus it would possible to screen them with a range of elicitors, including PAMPs and DAMPs.

In the proposed research, we aim to identify PAMPs from the downy mildew pathogen and DAMPs from the infected Arabidopsis tissues. In addition, we will search for possible receptors in Arabidopsis for these molecules.

University of Worcester

Key References

Chisholm, S. T., Coaker, G., Day, B. and Staskawicz, B. J. (2006) Host-microbe interactions: shaping the evolution of the plant immune response. Cell 124: 803-14

Lotze, M.T, Zeh, H.J., Rubartelli, A., Sparvero, L.J., Amoscato, A.A., Washburn, N.R., Devera, M.E., Liang, X., Tör, M. and Billiar, T. (2007) The grateful dead: damage-associated molecular pattern molecules and reduction/oxidation regulate immunity. Immunological Reviews 220: 60 – 81.

Tör, M., (2008) Tapping into molecular conversation between oomycete pathogens and their host plants. European Journal of Plant Pathology. Accepted.

Wang, G., Ellendorff, U., Kemp, B., Mansfield, J. W., Forsyth, A., Mitchell, K., Bastas, K., Liu, C., Zipfel, C., Woods-Tör, A., M. de Wit, P. J. G., Jones, J. D. G., and Tör, M. and Thomma, B. P. H. J. (2008) A genome-wide functional investigation into the roles of receptor-like proteins in Arabidopsis. Plant Physiology, 147:503-517.

Tör, M., Lotze, M. T. and Holton, N. (2009) Receptor mediated signalling in plants: molecular patterns and programmes. Journal of Experimental Botany 60: 3645 – 3654

Zipfel, C. (2009) Early molecular events in PAMP-triggered immunity. Curr Opin Plant Biol. 12: 414-20.

Zipfel, C. and Robatzek, S. (2011) Pathogen-associated molecular pattern-triggered immunity: veni, vidi...? Plant Physiol. 154: 551-4.

Segonzac, C. and Zipfel, C. (2011) Activation of plant pattern-recognition receptors by bacteria. Curr Opin Microbiol. 14: 54-61.

Rouxa, M., Schwessinger, B., Albrecht, C., Chinchilla, D., Jones, A., Holton, N., Malinovsky, F. G., Tör, M., de Vries., S. and Zipfel, C. (2011) The Arabidopsis leucine-rich repeat receptor-like kinases BAK1/SERK3 and BKK1/SERK4 cooperate to regulate innate immunity. Plant Cell 23: 2440-2455.

Qualifications needed

Essential:

- Applicants should have (or expect to receive) a First or Upper Second Honours Degree or an MSc in Biology/Microbiology or a closely related and relevant discipline;
- Proficiency in oral and written English;
- Computer literacy;
- Ability to organise and meet deadlines;
- Good interpersonal skills;
- Ability to work independently and contribute to a team;
- Commitment and an enthusiastic approach to completing a higher research degree

Desirable:

- Education to Masters Degree level in an Biology/Microbiology/Plant Sciences related discipline;

It is an expectation that the successful candidate will participate fully in the activities of the Institute of Science and the Environment, and gain additional experience in the teaching and research environment of the University.

Facilities: This research studentship is fully funded by the University of Worcester. During your time at Worcester, you will be provided with your own computer and an office space, which you will normally share with other full-time research students. Your office will normally be located in the The National Pollen and Aerobiology Research Unit (NPARU). NPARU is a designated research centre of the University of Worcester (UW) involved with Health, Science, Environment and Forensics. NPARU is part of the Institute of Science and Environment (ISE) at Worcester University, which is currently responsible for a wide range of courses including degrees in Biological Sciences, Forensic and Applied Biology, Environmental Sciences, Physical and Human Geography, and Archaeology & Heritage Studies. NPARU primarily conducts research and consultancy on topics related to Aerobiology, including infectious diseases, air quality and health, pollen monitoring and forecasts for the UK media and Met office, respiratory allergies, forensic palynology and testing appliances for allergen removal/reduction. NPARU is unique in the UK and has earned a national and international reputation for its combination of expertise in allergens, aerobiology, indoor air quality and medical knowledge.

Our supervisory strategy includes individual supervisory meetings with the Director of Studies and other supervisors as needed. Progress reports are completed annually. Whenever possible, our students are encouraged to present their work as posters or talks at meetings, symposia and conferences. You are expected to spend some time at the Sainsbury Laboratory to carry out part of the research.

The director of studies will be Dr. Mahmut Tor (National Pollen and Aerobiology Research Unit), with Dr Cyril Zipfel, The Sainsbury Laboratory, Norwich Research Park, Norwich, UK, and Dr Lee Bryne (Institute of Science and the Environment) as internal supervisors. All three supervisors have a particular interest and research experience in the relevant areas. They have extensive experience in supervising students at PhD level.

Bursary: You will receive a tax-free bursary of £12,300 for a period of 3 years plus an expenses budget. Fees will be paid in full at the UK/EU rate for home and EU citizens.

The Interview: The interview will provisionally be held Weds 25th April 2012. All successful applicants will be interviewed. The interview normally lasts around 3 hours in total and includes a meeting with the project supervisor(s), a chance to talk to some of our full-time students and an opportunity to view the campus and Institutional facilities.

Widening Participation: As part of its mission statement the University is committed to widening participation for its higher degrees. Although most candidates will have an undergraduate and/or a Masters degree, the University is happy to accept applications from candidates with relevant professional qualifications and work related experience.

Application forms are available at: http://www.worcester.ac.uk/discover/phd-studentships.html

For further information or an informal discussion on this project, please contact (m.tor@worc.ac.uk)

If you have any questions regarding the application process, please contact Mrs Helen Tabinor, Graduate Research School Manager (tel: 01905 855012, email: h.tabinor@worc.ac.uk).

Completed application forms should be sent by email to: research@worc.ac.uk or sent to: Graduate Research School, University of Worcester, Henwick Grove, Worcester, WR2 6AJ, UK