The Death of Plant Cells: From proteases to Field Applications, October 2013

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Running title: Barcelona 2013 plant PCD meeting report

Introduction

PCD with a focus on proteases. Why timely?

The meeting was jointly organized by B·Debate, Centre for Research in Agricultural Genomics (CRAG) and the Flanders Institute for Biotechnology (VIB) and aimed at bringing together outstanding local and international researchers working on plant programmed cell death, agricultural biotech companies, and animal programmed cell death experts, in Barcelona, Spain. The meeting was successful in promoting discussion, coordinating efforts and establishing national and transnational collaborations to boost the understanding of this key process. This is instrumental in directing future key questions concerning plant programmed cell death and to increase the visibility of this research field. Additionally, the aim to translate novel findings to crops, will contribute to meet the needs of the world's growing population in a sustainable manner.

This short article reviews the key points raised in two debates held during the meeting, where the challenges and future of the research in plant programmed cell death were discussed.

Parallelisms between plant and animal PCD

The initial believe that PCD in mammals would be conserved in plants and therefore of use for the translation of knowledge turned out to be untrue and even detrimental to the development of PCD research in plants. This belief has already been voiced before but gained consensus in the debate participants from both the mammal and plant communities. As Pierre Golstein (Centre d'Immunologie de Marseille-Luminy, Marseille, France) pointed out, probably there are common principles for PCD in different systems and organisms but the acting molecules are not necessarily common. Notably, this is the case for caspases, which are not conserved in plants. Accordingly, Guy Salvesen (Sanford-Burnham Medical Research Institute, La Jolla, USA) lamented the misleading naming of metacaspases and urged to use the term DEVD-ases in plants, instead of caspase-like activities . Richard Vierstra (University of Wisconsin-Madison, Madison, USA) added to this that 'discovering *BCL2* (an orthologue of the animal gene responsible for xx) was probably the worst thing to happen to plants' and that the mammal PCD paradigm in plants is history.

According to Guy Salvesen, the type of cell death described in plants is mostly a kind of terminal differentiation, rather than programmed cell death. Owing to the definition of PCD, Renier van der Hoorn (Max Planck Institute, Cologne, Germany) mentioned that he had not seen many studies showing that plant cell death can be blocked, as one would expect for a programmed process. A notable exception here would be hypersensitive response (HR) cell death.

Problems and bottlenecks in plant PCD research

Many participants agreed that it may be too early to discuss problems and bottlenecks in plant PCD research, since not enough studies have been published to date. Peter Bozkhov (Uppsala Biocenter, Uppsala, Sweden) said this might be because there is not enough motivation to study PCD in plants, in contrast to mammals, where it is linked to cancer research. One could argue that the study of PCD in relation to plant development and biotic and abiotic stress resistance may be of high importance for food security and the society at large. P. Bozkhov added that the study of plant PCD needed more time and more model systems According to Morten Petersen (University of Copenhagen, Copenhagen, Denmark) the lack of studies might also explain why there still is no systematic overview of cellular and molecular events during plant PCD, nor a detailed comparison of different forms of plant PCD, which would be instrumental in providing a framework for future research.

Susana Rivas (French National Institute for Agricultural Research, Toulouse, France) raised the question that besides the 'how & what', the 'why' has not sufficiently been addressed yet in plants. For example, why is bacterial growth not affected in plants with impaired HR ? This concern was also raised by Pierre Golstein who added that induction and cause of cell death are not the same.

The future of PCD

There has been a common outcry to make more use of inducible systems for the study of plant PCD. As Morten Petersen pointed out, genetic markers or use of specific genetic backgrounds have limitations which are sometimes forgotten. Plants are quite plastic and will acclimate, leading to the observation of pleiotropic or secondary effects. The discovery and implementation of these inducible systems might proof to be valuable to the community.

Another common wish has been the implementation of other model organisms. Pierre Golstein put things in perspective. There are only some ten model systems used in PCD research, but they were not selected to study this process and are not representative of the variability in eukaryotes. For example, apoptosis is a rare event found mainly in mammals.. We could specifically select new models looking for new forms of PCD, but concerns were raised on how this research would be financed. Technological advances that were discussed as key in future research included the increasing use of proteomic approaches, such as N-terminomics/degradomics to discover protease substrates, peptide chips covering entire proteomes and advanced protease activity probes. In the near future, according to Guy Salvesen and Renier van der Hoorn, chemical activity probes are expected to become incredibly specific, thanks to new design approaches such as peptidomimetics, unnatural amino acids, etc. Genetically encoded activity probes, mostly based on green fluorescent protein technology, have proven to be of more limited use but will continue to be used together with chemical probe for a comprehensive analysis of protease function during PCD.

Crop improvement and PCD

As an agricultural biotech representative, Fabien Poree (Bayer CropScience, Frankfurt, Germany) claimed for re-establishing the interaction between companies and universities, which had been more fluent in the past in spite of inherent difficulties. This lack of contact may be the cause that most research presented in the meeting is far from application. However, Fabien Poree stated his interest in plant cell death in views of its application in weed or pathogen control. For instance, chemicals that would influence HR type cell death might proof to be interesting targets.

Isabel Diaz (CBGP, Madrid, Spain) agreed that the field is often far away from applications but illustrated how proteomic studies could open interesting avenues in plant pest control. **Building a plant PCD community**

Most participants agreed that it was time to join efforts to better structure the plant PCD community.

As Richard Vierstra explained, we might take example of the proteolytic field (proteasome research) that separated along the years into proteaseome, ubiquitin and autophagy subfields. Sophien Kamoun

(Sainsbury Laboratory, Norwich, UK) agreed but stressed that creating a community should be seen as bringing people together rather than separating from others. He proposedthat the community be limited to plants to keep from ‘mimicking’ the mammal PCD field, but thatwe should keep on inviting guests from the mammal PCD field.

“The death of plant cells” was seen by many as a nice title to bring together the plant PCD community. Karen Mcluskey (XXX) and other speakers proposed that a series on this topic be organised with a different subtitle each time, which would slightly change the focus of the meeting. After the success of the meeting in Barcelona, it is envisioned that this event is repeated in the future and contributes to structure the plant PCD community. Options for community and next meetings. Plant PCD – protease dualism.Other initiatives that will be launched include creating a mailing-list (e-mail moritz.nowack@psb.vib-ugent.be to be included), website, gordon conference series?