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Foreword

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Sustainable disease management in a European context

The main theme of the book is sustainable disease management in a European context. Of course the issues are global and the papers reflect this. Some of the questions addressed are: How does society benefit from plant pathology research? How can new molecular approaches solve relevant problems in disease management? What other fields can we exploit in plant pathology research? What challenges are associated with free trade across the new borders? How can we contribute to solving problems of developing countries? How does plant pathology contribute to food quality and safety? How does globalization/internationalization affect teaching and extension in plant pathology?

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The authors of papers in this special issue of European Journal of Plant Pathology were selected among the invited speakers at the 8th Conference of the European Foundation for Plant Pathology & British Society of Plant Pathology Presidential Meeting 2006[1] that was held at The Royal Veterinary and Agricultural University[2], Copenhagen from 13th–17th of August 2006. This was an intimate conference attended by some 200 largely European delegates from more than 30 countries. The result of the conference and of this volume is an insight into the diversity of problems facing pathologists and the remarkable progress made in recent years. This book is intended to be more than a proceedings volume, and clearly, given the breadth of the subject, it represents a series of readings and not a comprehensive account of the state of research in the field in the middle of 2007 (the deadline for submission of these articles) or even of the excellent research presented at the conference that has not resulted in a paper in this special issue. There are many interesting relevant topics that were not presented at the conference — an obvious example is toxins in our food. Notwithstanding this, we believe the authors have provided a useful series of review articles and case studies of many key areas that we hope can

[1] http://www.efpp06.kvl.dk/index.html

[2] Now the Faculty of Life Sciences, the University of Copenhagen.

inspire future research. We have asked the authors to prepare the papers so that they can be used as teaching material for advanced courses and are well satisfied with the result.

We have organised the papers in four sections. As in all classifications of biological material, there is ambiguity as to the correct order and precise classification: alternative models would be entirely appropriate.

The first and largest section **How can biotechnology contribute to sustainable development?** presents an overview of the biological knowledge obtained using molecular biological techniques of the nature of plant-microbe interactions. We start with a review by Collinge et al. of the success stories, progress and challenges associated with developing transgenic disease plants. Weed resistant or rather herbicide and/or insect resistant crops have been grown extensively in various parts of the world, though largely not in Europe, for over a decade, and the area increases annually. Cultivated transgenic disease resistance crops are currently restricted to virus-resistant papaya and courgettes (zucchini) in the USA. The biological — and political — reasons for this are presented and discussed. The techniques of molecular biology and molecular genetics continue to provide an ever deeper understanding of the nature, recognition and regulation of the active and passive defence mechanisms protecting plants from pathogens. Two papers delve into different aspects of the regulation of disease defence mechanisms. Goellner and Conrath review the priming of defences and innate immunity, and in the process cover both the molecular basis of different forms of induced resistance to pathogens and pests and practical experience with the application of the concept. Tameling and Takken consider the downstream signalling associated with race-specificity. Recent knowledge shows how these processes respond to targeting by pathogen effector proteins — of which avirulence gene products represent a special case. The traditional models for and our understanding of Flor's gene-for-gene hypothesis are brought into context. The use of tools of functional genomics to study defence responses are illustrated by Collinge et al. and exemplified by a case study with the NAC transcription protein family of barley in the next paper. Two papers by Shetty et al. and Pruvsky highlight the importance of reactive oxygen species (ROS) in defence and signalling processes. The former reviews the current knowledge of ROS — as directly antimicrobial defences, as signals inducing defence responses and in oxidative cross-linking. The latter looks at the role of ROS and other factors in the switch from quiescent to necrotrophic interactions. The implications for control of post-harvest diseases are discussed. Both these papers challenge the simple classification of pathogens into biotrophs, hemibiotrophs and necrotrophs. The final paper in the section, by Ludwig-Müller and Schuller, concerns the study of *Plasmodiophora brassicae*, a fascinating organism quite unlike most of the pathogens we meet, and the use of the model plant *Arabidopsis thaliana* in its study. The major output described in the papers of this section is still fundamental biological knowledge where comparative genomics is an emerging theme. The real and projected impact of this knowledge in combating plant pathogen interactions is discussed.

The second section concerns **Strategies for disease control**. Jørgensen et al. present an analysis of the actual needs and habits of different types of farmer in order to optimise disease control in cereals. The advisory service integrates disease resistance information with fungicide recommendations. Organic agricultural systems are not concerned with the use of fungicides. Two papers consider alternative strategies appropriate for organic growers and provide interesting case studies. Slusarenko reviews the control of plant diseases by natural products and exemplifies this with Allicin from garlic. Finally, Whipps et al. present and review the mycoparasite *Coniothyrium minitans* as a biocontrol agent.

Under the title **Quarantine and diagnostics**, the third section addresses the issues of global pathogen spread. Despite our level of knowledge, new threats from pathogens continue to emerge, resulting in the spread of disease to agricultural systems and natural ecosystems around the world. Both increased free trade and climatic change contribute to these developments. Petter et al. review the progress made to harmonise methods for diagnostics and provide access to the materials developed. Thrane describes the implementation of these tools and provides a case study: potato testing in Denmark. Two papers in this section present two modern methods for diagnostics and identification of pathogens that allow rapid diagnosis of problems without the need for the taxonomic and identification skills developed through a life-time of study of diverse pathogens. Thornton describes the use of monoclonal antibodies for

detecting fungi (*Trichoderma* spp.) in soil and compares their use to other techniques, *e.g.*, nucleic acid-based methods. The use of these methods for following population dynamics and quantities of fungi are discussed. Boonham et al. look at the development and prospects of generic platform technologies, specifically Real-Time PCR, for diagnostics. The final paper of the section by Smith et al. shows how information on new outbreaks can be used globally but, using Africa as a case study, also discusses the global challenges facing agro-industry and quarantine systems.

The final section concerns **Population diversity and dynamics**. Disease resistance is the most effective form of controlling disease, when available. Plant breeding strategies for disease resistance are dependent on an understanding of the diversity of the pathogen population with respect to the frequency of avirulence genes to which the crop is exposed. Hovmøller describes the impact of virulence surveys — mapping virulence specificity (i.e. avirulence genes) in *Puccinia striiformis* populations in Denmark and the use of the data in dissemination to breeders and farmers. Kaur et al. describe how molecular biological methods have developed as essential tools in efficient plant breeding for disease resistance, and cover both the methods now available for identifying allelic variation (eco-TILLING) and the use of molecular markers in the breeding process. Wheat resistance used against powdery mildew is the case study described. Finckh advocates breeding for resistance diversity to provide the rationale for exploiting and implementing resistance.

The future for plant pathology

So what are the most significant advances made in the last few years and what challenges remain?

An increased understanding of the nature of race specificity is currently emerging. It is increasingly clear that resistance genes can function in two ways. They either recognise pathogen molecules directly, or recognise the effect of the pathogen molecule on the host cell. These pathogen molecules are now called effector proteins. A subset of these can be recognised by the host and they are then called specific elicitors, which are coded by the pathogen's avirulence genes. Race specificity is now considered to represent a second level of defence which functions to guard the primary mechanisms of resistance, now commonly known as innate immunity, from being disarmed by the effector molecules produced by the pathogen. At the same time, molecular genetic analyses, especially but not exclusively, in *Arabidopsis*, have vastly expanded our knowledge of the nature and regulation of distinct forms of induced resistance. In other words, several distinct, but interacting (i.e. so-called 'crosstalk') signal transduction pathways have been identified which regulate the defence responses activated by plant pathogens. The challenge now is to put this fascinating knowledge to use.

The increased knowledge of microbial genomes has not only led to major revisions in the taxonomy of plant pathogens but also to the development of molecular diagnostic tools, for instance gene chips — i.e. microarrays which allow specific identifications and PCR-based tools. These tools are useful in some systems but there are still many challenges for other pathogens, especially for asexual organisms where closely related organisms that cause diseases on different crops can be difficult to distinguish. We are getting closer to the idea of being able to put diseased material into one end of a machine and obtain a printout of the probable diagnosis from the other end. This would provide a cost-effective solution and bring diagnostics to technicians rather than letting it remain in the hands of a few specialists. These developments are welcome as increasing free trade can facilitate more rapid spread of pathogens between continents and the more variable climates we seem to be experiencing that are attributed to global warming create new habitats for pathogens in regions where particular pests and pathogens can find new niches.

Major progress has been made in the development of models for forecasting the development of diseases both between and within seasons. This can have considerable impact in the development of decision systems for farmers in terms of which varieties to plant in the next season, and how and when to spray. A major challenge is to devise the means for providing appropriate input data for the models. A challenge for the industry is the increasing costs of the development of new pesticides versus the potential for profit.

Plant pathology can both benefit from and contribute to biotechnology. In industrial countries, plant

pathogens are emerging as a resource for new enzyme products for preparing biomass for biofuels. The study of the biochemistry of the complexity of cell walls and the tools that pathogens use to degrade them are one of many opportunities for plant pathologists. We hope you are inspired.

A challenge for the subject of plant pathology lies in the way the universities and research institutions worldwide are funded. In an increasing number of countries, assessment systems and the division of resources is based on impact factors and the like, rather than societal benefit. The field of plant pathology covers both fundamental research and finding solutions for problems facing growers. The impact of our work is not always measured in citations in the scientific literature but in increased yields of healthy crops. Universities often appoint new lecturers on the former criterion. This is a worrying trend. In addition, although the numbers of university students continue to increase worldwide, the interest in biological sciences and agriculture is waning among the young. As a profession it is vital that we continue to demonstrate that the research and teaching that we perform reaches our targets — society, the industry and students, and that the benefit of our efforts is visible to society. We hope this volume contributes to these aims and needs.