British Society for Plant Pathology
Presidential Meeting

Metropolis, *Arcadia or* Dystopia:

visions of plant disease management in 2050?

A discussion meeting over two days

17th-18th December, 2013

Facilitated discussion
Disease control chemistry long-term – GM –
land sharing or land sparing –
precision treatment – trade, stability and invasions –
political and economical landscape

BSPP

British Society for Plant Pathology
BSPP

President's Welcome

Welcome to this year's BSPP Presidential conference.
Plant pathology arose from the need to be sure of food supplies and the disasters of the 19th century. With recent invasions of disease and unease about the future of food supply in the face of climatic shifts and increasing population, there is unusual public awareness of the science. The application of pathology to disease management remains its public face, but for many in the field the focus of scientific excitement is now the unravelling of the inner workings of host–pathogen relationships. Many hope this will provide tools which will eliminate the need for any further management of disease. I hope they are right; personally, I doubt it.
The aim of this conference is to help those attending set their work in a context of the kind of world we may see – or want – in the medium future: too far ahead to say what will actually be happening, but not so far that discussion gives way to fantasy. We have allowed more time than usual for discussion, and will be structuring the discussion to try and ensure everyone can have effective input. We have asked speakers to cover a range of aspects of future disease management. We hope that the ideas presented will stimulate discussion in the formal sessions, over refreshments, and beyond the conference.

Michael Shaw

Organising committee:
Mike Shaw and Steve Whisson

We wish to thank Sarah de Vos for the design of the front cover image, Carol Jenner for compilation and layout of the programme booklet, the communications team at the James Hutton Institute for printing, and the Conference Aston team for on-site organisation.

BSPP Presidential Meeting 2013: Visions of plant disease management in 2050: metropolis, arcadia or dystopia?
Aston Business School Conference Centre and Hotel, University of Aston, Birmingham, UK

17 December

1000 Arrival and registration

Session 1 Chair: Lesley Torrance (The James Hutton Institute)

1100 BSPP Presidential Address: 'Prediction, metaphor, scale and purpose in plant pathology' [**Michael Shaw**, University of Reading, UK]

1200 Lunch

Session 2 Chair: David Collinge (University of Copenhagen)

1315 Presentations for the P H Gregory prize for best talk by an aspiring or newly graduated PhD

Helen Brewer, Rothamsted Research, UK. 'A magical molecule? Resistance to Fusarium ear blight fungi in *Arabidopsis* floral tissue associated with accumulation of L-homoserine'

Rachel Warmington, University of Warwick, UK. 'Biofumigation to control sclerotinia disease in vegetable crops'

Rebekah Robinson, Rothamsted Research, UK. 'Bacterial endophytes in wheat: isolation, community structure and *in planta* localisation'

Siti Nordahliawate, University of Hertfordshire, UK. 'Effects of host resistance on maturation of pseudothecia of *Leptosphaeria* spp. (cause of phoma stem canker) in *Brassica napus* (oilseed rape)'

James Stroud, Bangor University, UK. '*Phytophthora infestans* on tomato: knowing thine enemy (and how to beat it)'

Xiaolei Jin, University of Hertfordshire, UK. 'Integrated control of strawberry powdery mildew'

Sarena Omar, University of Oxford, UK. 'Characterizing the cell wall of the rice blast fungus'

1500 Coffee and tea

1530 Poster session (including J Colhoun poster prize)

Concurrently: BSPP Annual General Meeting (Conference Room 1a)

Session 3 Chair: Michael Shaw (University of Reading)

1730 Garrett Memorial Lecture and APS speaker 'Disease management futures: the political and economic landscape '[**Christopher Mundt**, Oregon State University, USA]

1830 Drinks and snacks

1900 Social and mixing dinner

18 December (9am – 5pm)

Session 4 Chair: Michael Lyngkjær (University of Copenhagen)

0900 Talk: 'Trade, invasion, climate change and the future of our forests and natural ecosystems' [**Clive Brasier**, Forest Research, UK]

0930 Talk: 'Disease control chemistry in the longer term' [**Naomi Pain**, Syngenta, UK]

1000 Talk: 'Designing the crops of the future - where will we be in 2040?' [**Anne Osbourn**, John Innes Centre, UK]

1030 Coffee and tea

1100 Facilitated discussion in rotating small groups,'world café' style. General theme: Is it realistic to imagine stable absence of disease? By what means? What means are best for society? What situations are most likely to arise?

1215 Lunch

Session 5 Chair: Rick Mumford (Fera)

1330 Talk: 'Land sharing or land sparing futures?' [**Ben Phalan**, University of Cambridge, UK]

1400 Interactive talk/discussion: 'Educating Margarita, Abdul and Mao too: plant diseases in the real world and the quest for practical solutions' [**Eric Boa**, CABI, UK]

1445 Talk: 'Precision pathology: the technological options' [**Jon West**, Rothamsted Research, UK]

1515 Talk: 'Future environments, plant community change and disease management' [**Adrian Newton**, James Hutton Institute, UK]

1545 Coffee and tea

1615 Closing discussion in small groups: career path ambitions and reflections. The aim is to swap visions and experience, especially between newer and older entrants to plant pathology

1650 Announcement of 2014 BSPP Presidential Meeting [**Lesley Torrance**] and closing remarks [**Michael Shaw**]

1700 Departure

Awards

The Board of BSPP wishes to encourage young plant pathologists to talk about their work. There are two prizes awarded at the presidential meeting:

The P H Gregory prize, awarded for the presentation of an oral paper. The competition is open to (a) members of BSPP who have not previously presented a paper to a meeting of a learned society and (b) to all registered postgraduate students, whether or not they are members of the society, or have presented a paper before to a meeting of a learned society. Contestants should not have entered the P. H. Gregory competition previously. The winner receives a certificate and a cheque for £250.

Philip Gregory (1907–1986) pioneered aerobiology as a topic for research, combining many disciplines to contribute to better understanding of fungal spore dispersal and plant disease epidemiology. He developed theories of spore dispersal, which was published in his classic paper on the dispersion of airborne spores (Gregory PH. (1945) Trans. Br. Mycol. Soc. 28: 26–72). He became Head of the Plant Pathology Department at Rothamsted in 1958 where he further developed his research on spore dispersal and sedimentation velocities. In his retirement, Philip Gregory continued work on elucidating the epidemiology of black pod disease of cocoa in Nigeria, and maintained enthusiasm for his wide range of scientific interests. He proudly and enthusiastically showed his garden to visitors and they often regarded this as the highlight of their visit to Harpenden (Source: Lacey *et al*. (1997) Ann. Rev. Phytopathol. 35: 1—14).

The John Colhoun Prize, awarded for a poster. The work presented in the poster must form part of a research project conducted by the entrant in support of a PhD or Masters degree, and the entrant must not have been awarded the degree prior to the deadline for abstracts date. Students need not be members of BSPP. The winner receives a certificate and a cheque for £100.

John Colhoun (1913–2002): cryptogamist and plant pathologist. John Colhoun was awarded a MAgr in 1937 at Queens University, Belfast, and then moved to Imperial College, London, working on fungal pathogens of apples for his PhD, awarded in 1940. He returned to Northern Ireland where he worked on flax, an important crop in the province during World War II, leading to a definitive text (Muskett A. E. & Colhoun J. (1947): The Diseases of the Flax Plant). He became reader at Queens University in 1954. Subsequently, he took up the Chair of Cryptogamic Botany at the University of Manchester in 1960, where he worked on *Fusaria*, *Phytophthora*, *Septoria* and *Phoma*, with hosts ranging from cereals to chrysanthemum, yam, oil palm, and banana. In 1968 he was elected Chairman of the Federation of British Plant Pathologists, forerunner of the British Society for Plant Pathology. He retired from Manchester University in 1980 as Professor Emeritus, having occupied the Barker Chair of Cryptogamic Botany for 20 years. (Source: Epton H. (2003) Mycol. Res. 107: 377–381).

Presidential Address

Prediction, metaphor, scale and purpose in plant pathology

Michael W. Shaw
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It is routinely stated that such-and-such a piece of research is essential to feed the world in 2050; it is less common to point out this depends on choices not yet made. Some of the world of 2050 is already determined: several regions of the world will be inescapably more populous; many new disease problems will have arisen because of the scale of trade in plants; and the climate will be different, in some places unpleasantly so, and everywhere inconveniently. But much of the future is still to be chosen. The metaphors we use to think with influence both our expectations and our research directions. “Disease control” and “disease management” suggest very different approaches to the problem of ensuring food, fibre and fuel supplies. If – at the back of our minds – we think a crop pathosystem is like a machine, we will seek to refine its inner workings, and expect it to respond in predictable ways. If we see it as two clashing armies, we may not look for or understand the subtler aspects of population regulation. If we see it as a part of a larger system, we risk ignoring how the detail of the pathosystem constrains its behaviour. In wider decision-making, the political goals implicit in choices are again metaphorical – as in the title of this conference. I hope this conference will provide a space to think widely about what we do and what kind of world we can move towards in the next half-century or so.

P H Gregory Prize Speaker

A magical molecule? Resistance to Fusarium ear blight fungi in *Arabidopsis* floral tissue associated with accumulation of L-homoserine

Helen C. Brewer, Nathan Hawkins and Kim E. Hammond-Kosack
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Fusarium ear blight (FEB) is a serious disease of small grain cereals, causing massive losses worldwide. The primary causal agents of FEB in the UK are *Fusarium graminearum* and *F. culmorum*. Both species infect the floral and silique tissue of *Arabidopsis thaliana*, providing a tractable model pathosystem for the study of *Fusarium*–plant interactions [1]. Previous studies showed that mutation of *Arabidopsis DMR1*, encoding homoserine kinase, led to accumulation of homoserine in leaf tissue and resistance to *Hyaloperonospora arabidopsidis* and *Oidium neolycopersici* [2, 3]. We report that multiple mutant alleles of *Atdmr1* also have increased resistance in silique and leaf tissue to *F. graminearum* and *F. culmorum.* We also find that homoserine accumulates in the siliques of *dmr1* plants but is absent from wildtype plants. Exogenous application of L-homoserine inhibits *Fusarium* disease development in the floral tissue of both *Arabidopsis* and wheat, but does not affect *Fusarium* growth *in vitro*. These findings provide evidence that a common susceptibility mechanism occurs during infection of *Arabidopsis* by both obligate biotrophic oomycete and hemibiotroph fungal pathogens, and is conserved in both vegetative and reproductive (floral) tissue. Furthermore, resistance induced by homoserine accumulation appears to be conserved between dicotyledonous and cereal (monocotyledonous) plant species. This has the potential to aid the development of cereal crops with enhanced resistance to FEB.

1. Urban M *et al*. 2002. *The Plant Journal* **32**, 961–73.
2. Huibers RP *et al*. 2013. *PLoS ONE*, **8**, e67467.
3. van Damme M *et al*. 2009. *The Plant Cell* **21**, 2179–89.

P H Gregory Prize Speaker

Biofumigation to control sclerotinia disease in vegetable crops

Rachel Warmington
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The ascomycete fungus *Sclerotinia sclerotiorum* is an important necrotrophic pathogen world-wide with a host range of over 400 plant species including economically important crops such as lettuce, oilseed rape, potatoes and carrots. The pathogen survives in the soil as sclerotia which when brought close to the soil surface germinate to produce apothecia from which then ascospores are released, infecting plants upon which further sclerotia are formed and are returned to the soil.
Control methods for sclerotinia disease are predominantly through use of fungicides, and cultural practices such as deep ploughing or crop rotations. Products such as Contans WG (*Coniothyrium minitans*) and Perlka® (calcium cyanamide) can provide long-term control against the disease by reducing the viability of sclerotia in the soil, but are generally considered too costly by growers. This research looks at whether biofumigation can reduce viability of sclerotia, and hence be useful as a new control approach.
In microcosm trials the biofumigant plant *Raphanus sativus '*Terranova' reduced carpogenic germination of sclerotia by 73% in comparison to the untreated control, which compares well to the positive control Perlka® which reduced germination by 82%. Results from *in vitro* trials indicated that this reduction in germination is caused by isothiocyanates being released from the plant material. However, the low glucosinolate oilseed rape cultivar *Brassica napus* 'Temple' also reduced carpogenic germination and HPLC analysis confirmed that it does not contain significant levels of glucosinolates. This suggests that there are other volatile compounds being released from 'Temple' which affect the germination of sclerotia.

P H Gregory Prize Speaker

Bacterial endophytes in wheat: isolation, community structure and *in planta* localisation

Rebekah J. Robinson[1], Tim H. Mauchline[1], Penny R. Hirsch[1], Robert W. Jackson[2] and Bart A. Fraaije[1]
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Endophytic bacteria colonise the internal tissue of living plants for at least part of their life cycle without causing symptoms of disease. Endophytes have several functions which may directly or indirectly result in plant growth promotion through biofertilisation, biocontrol or phytostimulation. To exploit the beneficial properties of bacterial endophytes a full understanding of the factors controlling microbial community structure, their plant beneficial traits, and niche occupancy within the plant is required. We used material from the Broadbalk experimental plots at Rothamsted Research to conduct a comparative study of culturable bacterial endophyte communities in winter wheat (cv. Hereward) under contrasting fertiliser regimes. Endophyte populations were profiled using 16S rRNA gene RFLP analysis. The endophytic compartment was found to lack some key phyla found in soil, but fertiliser treatment was shown to have little effect on phylum distributions in the roots. We found greater abundance of Firmicutes and Actinobacteria in the shoots than the roots and at the genus level found limited association of specific genera to treatments. This indicates that soil is the main source of bacterial endophytes but there is a degree of endophyte adaptation and host control during colonisation. Current work aims to identify colonisation sites and niche occupancy for a selection of the endophytes. A number of these have been tagged with genes encoding fluorescent protein markers (*egfp* or *mCherry*) or the *uidA* (*gusA*) reporter. We are using epifluorescent microscopy, confocal microscopy and histochemical staining to visualise endophytes within the wheat plant tissue.

P H Gregory Prize Speaker

Effects of host resistance on maturation of pseudothecia of *Leptosphaeria* spp. (cause of phoma stem canker) in *Brassica napus* (oilseed rape)

Siti Nordahliawate, Bruce D. L. Fitt, Avice M. Hall and Yong-Ju Huang
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The severity of phoma stem canker epidemics on winter oilseed rape in summer is greatly influenced by timing of ascospore release in the previous autumn. It is known that weather (temperature and rainfall) influences timing of ascospore release. This work investigated the effect of cultivar resistance on pseudothecial maturation (ascospore release) in natural conditions for two seasons and in controlled environment conditions. In autumn 2011, there were no differences between cultivars in pseudothecial maturation after a period of dry weather in September. The first ascospores were released in the third week of January 2012 after 51.9 mm rainfall in December 2011. In autumn 2012, however, there was more rainfall from September to December (total rainfall 158.9 mm) than in 2011 and the pseudothecia of the susceptible cv. Drakkar matured much faster than those of the more resistant cultivars. The first ascospores were released in early October 2012. In autumn 2013, the major release of ascospores started on 18 October and the observation of pseudothecial maturation is in progress. In controlled environment conditions, pseudothecia matured much faster on cv. Drakkar than on other cultivars. The differences between cultivars in pseudothecial maturation have implications for the subsequent severity of stem canker. Therefore, it may be necessary to modify the current forecasting web-site system (http://www.rothamsted.ac.uk/Content-Section=Leafspot.html) to include a factor for cultivar resistance.

P H Gregory Prize Speaker

Phytophthora infestans on tomato: knowing thine enemy (and how to beat it)

James Stroud[1], Katherine Steele[1], Mike Hale[1], David Shaw[2] and Simon Crawford[3]
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Late blight disease, caused by the oomycete *Phytophthora infestans*, is one of the most important diseases of potato and tomato. *P. infestans* normally reproduces asexually, and populations frequently include a number of clonally reproducing genotypes. Evidence exists that the frequency of *P. infestans* genotypes varies from one host species to another in many areas. Whilst the genotypic composition of *P. infestans* on potato has been well studied in Great Britain, this is not the case with *P. infestans* on tomato. This study attempts to determine whether a subset of tomato-adapted *P. infestans* genotypes exists in Great Britain, and ultimately to develop tomato cultivars with resistance to them.
Samples of *P. infestans* were collected from tomato around Great Britain, and genotyped using SSR markers. Samples collected in 2011 and 2012 suggest that genotype 23_A1, which is rarely found on potato crops, is far more common on tomato, whilst genotypes 13_A2 and 6_A1, (which made up most of the samples collected from potato crops in recent years) were much less common on tomato. Results of a similar survey carried out in 2013 will also be presented.

P H Gregory Prize Speaker

Integrated control of strawberry powdery mildew

Xiaolei Jin, Bruce D. L. Fitt, Avice M. Hall and Yongju Huang
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Strawberry powdery mildew caused by *Podosphaera aphanis* has the potential to cause more than 20% yield loss, particularly where strawberries are grown under cover. The use of silicon (as a silicon wetter), either as a spray in the field or as a nutrient added to the fertigation system, produced changes in plant structure including increased leaf thickness and leaf hair number, which improved defence against *P. aphanis*. The spray trial indicated that the high rate (0.5% v/v) silicon wetter alone controlled the existing epidemic of *P. aphanis* after 4 weeks ($P < 0.05$). The low rate (0.25% v/v) gave little disease control when compared with the untreated control. The fertigation trial indicated that the silicon wetter (0.017% v/v) added to the fertigation water twice a week for 13 weeks also produced similar structural changes in the leaf and enhanced the plant defence mechanisms leading to a delay of two weeks in epidemic development. Analysis for silicon in the plants at the end of the trial showed that there were increased concentrations of silicon in leaves, petioles, peduncles and fruit in silicon treated plants by comparison with the untreated control plants. The fertigation trial suggests that the use of silicon as a nutrient could be integrated into routine strawberry production so that disease control is achieved with less use of conventional fungicides.

PH Gregory Prize Speaker

Characterizing the cell wall of the rice blast fungus

Sarena C. Omar[1] and Sarah J. Gurr[2]
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Rice blast disease caused by the fungus *Magnaporthe oryzae* is responsible for 10–30% loss in annual yield, enough to feed the whole of the UK for one year. In 2012, it was voted the most economically and scientifically important fungal pathogen by pathologists. The projected rise in global food demand coupled with occurrence of disease in resistant rice cultivars justifies the need for new control strategies.

The fungal-specific cell wall is a dynamic structure and potential target. Besides providing mechanical support, it is also plastic, an important feature essential for morphological changes during growth, infection and reproduction. This plasticity is achieved through specialised cell wall remodelling enzymes such as Gelp and CRHp bounded within the meshwork of the cell wall.

Antifungal drugs targeting the cell wall of pathogens causing candidiasis and aspergillosis in humans have been successfully studied and developed. However, little is known regarding cell wall composition, physical properties and importance for virulence in fungal plant pathogens.

Quantitative RT-PCR showed *Magnaporthe oryzae CRH* genes were up-regulated ($P < 0.05$) during vegetative growth and when under cell wall stress. This data is further supported when *MGG_CRH2* knockout mutant exhibited 20–30% ($P < 0.01$) reduction in growth when grown under the same conditions. Pilot pathogenicity analysis showed mutants able to infect hosts, but with reduced rate of disease spread *in planta*. Further work will include atomic force microscopy to elucidate the importance of CRHp in cell wall plasticity, fluorescent tagging for protein localisation and mutant sensitivity against commonly used fungicides.

Garrett Memorial and APS Speaker

Disease management futures: the political and economic landscape

Christopher C. Mundt
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Plant pathology has a crucial role to play in developing sustainable systems to address the coming challenges posed by increased demand for food and fibre, changing climate, and exponentially increasing movement of pathogens via global trade. The pressure to "get it right" is very high. None of us alone has the answers to these challenges, but I hope to foster thought and discussion that will contribute to progress in addressing them. Examples of pertinent questions include: Is sustainable disease management best accomplished as an engineering approach or via management of ecological and evolutionary processes? What is the proper balance of lab-based versus field-based research and computation versus experimentation? Are we asking the right questions as plant pathologists? Are we focusing our efforts on what we find most exciting scientifically versus what is needed to develop better approaches to disease management? How do we best balance inquiry for its own sake versus issues that need immediate attention? More importantly, how can we better integrate these two aspects of our profession to capitalize on the resulting synergism? What is an appropriate balance between public and private research? Can we revitalize IPM in plant pathology? How can we improve our success rate in actually accomplishing improved disease management? I will attempt to address such questions from the perspective of a plant pathologist who has greatly enjoyed a career in disease management, but who also has struggled considerably with the diverse responsibilities of our profession and the sometimes conflicting needs of science versus society.

Invited Speaker

Trade, invasion, climate change and the future of our forests and natural ecosystems

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Introductions via the plant trade of damaging exotic tree pathogens, many previously unknown to science and most of them uneradicable, have increased dramatically over the past two decades. Ash dieback is merely the latest example. Climate change scenarios for 2050 suggest enhanced activity of *Phytophthora* pathogens and other increased stresses on trees. Such pressures have brought the threats to the future of our forests and natural ecosystems into sharper political focus, but to date convincing solutions remain elusive. Indeed, the UK forestry sector is now in something of a crisis over how to future-proof its woodlands in the context of these uncertainties. A major question is how to build long term climatic resilience into forests when the future silvicultural deployment of preferred species choices (e.g. larch, oak, ash, pine) is highly uncertain because of introduced pests and pathogens, a legacy of single species stands and a decline in forest husbandry. The history, nature and scale of the issues, including lessons often not learned, will be discussed. Some suggestions will be made on the way ahead – but attempting to predict the future against a background of rapid demographic, economic and environmental change is itself high risk.

Invited Speaker

Disease control chemistry in the longer term

Naomi A. Pain
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As the demand for food supply to support an increasing population grows, fungicides will continue to be a tool in our armoury for securing stable food supplies.
The next 40–50 years will see considerable change: agricultural systems are evolving as new technologies are adopted, shifts in disease pressure occur, consumer demand for year-round availability and quality of crops increases and regulatory requirements change. From a review of the recent trends in the fungicide market and short-term projections, an extrapolated view of challenges and opportunities ahead and the potential chemical solutions of the future will be presented.

Invited Speaker

Designing the crops of the future – where will we be in 2040?

Anne Osbourn
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Agriculture must become more efficient in the very near future in order to be able to support the global population as it grows by 40% to beyond 9 billion by 2050. Genetic modification of crop plants in the broadest sense can be carried out using 'traditional' plant breeding approaches (including the generation of hybrids and induced mutagenesis) and through the generation of transgenics. Biotechnology will have a critical and essential contribution to make in ensuring food security through crop protection and trait improvement, as well as in protecting the environment and helping to mitigate the effects of climate change. To date, seed improvement has for the most part relied on traditional breeding. Biotechnology-based approaches have tended to focus on single gene input traits. Recent advances in synthetic biology now offer opportunities for crop improvement through genome editing and precision gene insertion, blurring the boundaries between traditional plant breeding and biotechnology even further. Not all agronomic problems can be overcome by modifying or engineering single genes. Advances in commercial DNA synthesis technology and DNA assembly methods are now allowing the rapid and facile assembly of complex synthetic loci for plant transformation, and plant synthetic chromosomes are becoming a reality. Synthetic biology offers the prospect of reprogramming plants and the rhizosphere for improved and sustainable bioproduction. This talk will attempt to look ahead to where we might be in 2040. Engagement processes that are balanced and evidence-based will have a critical role in shaping the way forward.

Invited Speaker

Land sharing or land sparing futures?

Ben Phalan[1], Andrew Balmford[1] and Rhys E. Green[1,2]
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Of all human demands on the biosphere, none has transformed the planet so much as the conversion of natural habitats for food production. There are no easy solutions to the challenge of reconciling biodiversity conservation and producing more food, but there is a range of options. Those options fall into two main categories: integrating conservation and food production on the same land (land sharing) and protecting or restoring natural habitats from agriculture while using increasing yields to minimise cultivated area (land sparing). I will discuss the latest evidence on how effective each of these strategies is likely to be for conserving wild species, the practical and political challenges involved in implementing such conservation strategies, and the most important uncertainties and gaps in knowledge.

Invited Speaker

Educating Margarita, Abdul and Mao too: plant diseases in the real world and the quest for practical solutions

Eric Boa[1] and Jeffery Bentley[2]
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What happens after you've got your first, second or even third degree? If you want to work in agriculture how useful will your knowledge and skills be in solving practical problems? If you stay in research, how might your results be used to improve management of plant diseases? I will discuss plant doctors, plant health clinics and building plant health systems from Bolivia to Nicaragua, Sierra Leone to Mozambique and Nepal to Vietnam. I will show examples of crippling plant diseases that are poorly unknown in the UK and Europe, but of critical importance to food security and people everywhere. We will be doing practical exercises and exploring simple techniques for field diagnosis and improving the quality of advice given to farmers. The aim of this hands-on session is to explore a new approach to an old problem: getting good advice on plant diseases (and plant health problems generally) to the people who need it. The overall approach is relevant to all farmers and production systems. Something for everyone and, I hope, an education for all.

Invited Speaker

Precision pathology: the technological options

Jonathan S. West[1,2]
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[2] Department of Life and Medical Sciences, University of Hertfordshire, Hatfield, AL10 9AB, UK
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In the past 40 years, aside from crop genetic improvements, we have seen changes in agronomic practices that affect crop diseases (fungicides, minimal-tillage, increased field and farm size, altered crop rotations). Complicated interacting effects of weather, proximity and availability of inoculum sources, and compatibility of pathogen races with crop varieties are just some of the factors leading to variation in disease epidemics. Precision agriculture and plant pathology has helped our management of diseases that occur in an apparently sporadic or patchy distribution and has great potential to help increase food production, which will be much needed by 2050. Information technology may help us to rotate varietal resistance effectively as an additional layer of crop rotation. Air and rain sampling can be automated with diagnostic methods and wireless communications, and integrated with infection models to provide a direct inoculum-based warning of imminent disease risk. Additionally, automated vehicles (robots) could operate at night, navigating by GPS or RF markers and using chlorophyll fluorescence to map positions of plant stress down to the sub-leaf scale. These or networks of fixed sensors could also use canopy reflectance, volatile biomarkers, *in planta* diagnostic tests and HD video imagery to classify or identify problems. Spatially selective spraying of crop protection products (biologicals or fungicides) may help with disease foci or crop patches that have low yield potential due to other factors. Crop protection in intensive production systems will be more important than ever to provide the lowest environmental impact per unit of produce harvested.

Invited Speaker

Future environments, plant community change and disease management

Adrian C. Newton
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The big issues under future environments will be driven by the consequences of climate change in regions where food production is already limiting whether through population pressure, poverty or resource limitation, primarily water. Population relocation will put pressure for production on still and newly favourable regions. Trade and policy changes will probably drive changes in diseases as much if not more than climate and whilst the latter are partially predictable as range changes, the former are less so. There will also be consequences of novel changes, mainly CO_2 increase.

We should prepare for the predictable with new durable resistance using all resistance breeding technologies, agronomic approaches and use of robust crop protectants. However, we can prepare for both predictable and the unpredictable by focusing on enhancing the resilience of our production systems, particularly increased use of heterogeneity applied at all practical levels. This is not the sole responsibility of the food producers; the entire supply chain should assign value to sustainability/ resilience. Marketing may need to lead this.

Pathogen control strategies should be to manage them as components of the microbial ecological community. Both above- and below-ground parts of plants represent numerous ecological niches for microbes. Resilient production systems will be characterised by niches being occupied by benign or beneficial microbes whereas so-called pathogens will be out-competed or retained in non-pathogenic state. We should manage the “trophic state” of the microbial community as well as their ecological niches so that control interventions are minimised whilst improving resource use efficiency and productivity.

J Colhoun Poster

Using next generation sequencing technology to search for novel viruses of wheat

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The potential for viruses to be a contributory factor causing the plateau in the yield of winter wheat in the UK has been investigated. The significant effect of viruses on wheat was confirmed in mechanical inoculation tests using *Cynosurus mottle virus* and wheat cv. Scout and Gladiator in which there was an 83% and 58% reduction in the number of grains produced compared to healthy controls, respectively. A large-scale survey of English wheat samples from the harvests of 2009–2012 using TaqMan assays targeted to viruses which have historically been identified in Gramineae in the UK concluded that such viruses were not highly prevalent. Therefore next generation sequencing (NGS) was used to search in a non-targeted manner within wheat, weed and insect samples from a site in southern England. While the results confirmed that currently known viruses were present but not at high prevalence, perhaps the most significant results were the potential detection of novel viruses, in particular one virus which was potentially detected in 25% of all the wheat samples tested. If confirmed to be a genuine virus, this could hold the key to unlocking the yield of wheat in the UK, because it could be acting as a cryptic virus that is highly prevalent in the UK, therefore capping the achievable yield. This study has highlighted that NGS tools such as pyrosequencing are potentially very useful in the identification of novel viruses within plants and insects.

J Colhoun Poster

Susceptibility and symptom development in different barley genotypes after infection with *Bipolaris sorokiniana*

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Fungi with a necrotrophic lifestyle are of increasing importance in crop production worldwide. The hemibiotrophic fungus *Bipolaris sorokiniana* causes spot blotch disease in small grain cereals and disease outbreaks have increased severely in areas that have become warmer and more humid within the last years. Phytotoxin release by *B. sorokiniana* is the causal agent of symptom occurrence in form of necrotic spots, and the number of spots is an indicator of disease severity. Mlo in barley is a G-protein coupled receptor that acts as a negative regulator of defence mechanisms. It has been implied that barley *mlo* mutants are more susceptible to fungal pathogens with a necrotrophic lifestyle, including *B. sorokiniana*. However, the role of *mlo* is not fully understood. We investigated symptom occurrence, fungal biomass and toxin sensitivity in barley to test the importance of the *mlo* mutation on susceptibility to *B. sorokiniana* in different genetic backgrounds. Our observations showed that variation in susceptibility was mainly due to the genetic background and *mlo* mutations only in some cases contributed to increased susceptibility. By manipulating light conditions during *B. sorokiniana* infection we observed that after incubation in darkness no symptoms occurred on the infected leaves and that these symptomless plants often had substantially higher amounts of fungal biomass, indicating that symptoms do not always correlate with fungal infection. This raises the question when and how toxins are valuable and needed for fungal infection and colonization, and highlights the need for a better understanding of the biology of *B. sorokiniana*.

J Colhoun Poster

Development and maturation of the chasmothecia of *Podosphaera aphanis* on strawberry

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Strawberry powdery mildew is caused by *Podosphaera aphanis.* The disease affects leaves, flowers and fruits, thus reducing strawberry yield, both in quantity and quality. The pathogen survival structures of *P. aphanis* are chasmothecia, which overwinter. The aim of this research project was to use knowledge about development and maturation of the chasmothecia throughout the year to refine a prediction system to give improved control of strawberry powdery mildew. The chasmothecia of *P. aphanis* develop in late summer/autumn in response to changes in environmental conditions. This work followed the development of chasmothecia and quantified the number and maturity of the chasmothecia in the field with different fungicide spray regimes. The number of chasmothecia and maturity of chasmothecia in September and March were greater in the field that received less fungicide sprays. The field sprayed more frequently with fungicides had fewer chasmothecia and fewer mature chasmothecia. There was a significant difference ($P < 0.05$) between the two fields in both September and March, demonstrating the efficacy of out-of-season fungicide sprays to reduce initial *P. aphanis* inoculum concentration. The changes occurring during maturation and time required for maturation at a constant temperature and humidity were recorded. During maturation, chasmothecia changed from white to dark brown as the ascus developed. This process took 10 to 11 days in a damp chamber at a constant temperature and humidity.

J Colhoun Poster

Efficacy of major gene resistance against *Leptosphaeria maculans* under varying temperatures

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Stem canker caused by *Leptosphaeria maculans* is an important disease in oilseed rape (*Brassica napus* L.) and causes significant yield losses. The cultivation of resistant cultivars is a reliable tool for protecting the crop against pathogen damage.
In this study the efficacy of major resistance genes against *L. maculans* was tested under varying temperatures for cotyledons and stems in controlled environment experiments. Therefore, the resistant cultivars Caiman with *Rlm7* resistance and Uluru with *LepR3* resistance as well as Lirabon as susceptible control were used. An avirulent and a virulent *L. maculans* isolate were selected for each resistant cultivar. Cotyledon resistance was tested with spore suspension, whereas adult resistance was tested at the stem base by inoculation with a mycelium plug. The plant–pathogen interactions were examined at different temperature regimes.
Incompatible interactions found on cotyledons of Uluru rendered to be more susceptible, whereas only an increase of *L. maculans* DNA was found for cotyledons of Caiman at higher temperatures (≥27 °C). The major resistance genes could actively reduce disease severity in stem tissue. Adult plants of Caiman were strongly dependent on major gene resistance, whereas Uluru relied more on quantitative resistance. High temperature treatment did not change incompatibility into compatibility at stem bases.

J Colhoun Poster

Sustainable strawberry production including the use of a rule-based prediction system for controlling strawberry powdery mildew

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UK strawberry production could be viewed as an example of sustainable intensification through the precision use of varieties, nutrients and polythene tunnels. Powdery mildew, *Podosphaera aphanis*, is a major fungal disease affecting strawberry production worldwide. Serious epidemics can reduce crop yields by up to 70% as a result of inadequate ripening of fruits, fruit deformation, poor flavour development and reduced storage time. The pathogen infects strawberries in nearly all organs and is specific to this crop. A rule-based prediction system based on temperature and humidity has been developed to predict High Risk Days to alert the grower when fungicide spraying is necessary. A field trial was carried out under a tunnel growing strawberries at a commercial farm in 2013 aimed to assess the efficacy of the prediction system on disease control. Weekly disease assessments were carried out from April to June. Results suggested that although the disease was reduced by spraying with fungicides, there were considerable differences between beds in the tunnel, which should be partly explained by differentiations of microclimate between beds. The study also calculated greenhouse gas (GHG) emissions of all pesticides used in the tunnel. Fungicides represented the largest contribution to GHG emissions. Results showed that Fenomenal and Trianosan DG produced higher levels of GHG emissions compared to the other fungicides used. The hypothesis is that use of a precision prediction system would enable disease control with fewer fungicide sprays, thus reducing overall GHG emission.

J Colhoun Poster

Pathogenicity of *Leptosphaeria biglobosa* to oilseed rape (*Brassica napus*) cultivars differing in resistance against *Leptosphaeria maculans*

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Field and controlled environment experiments were done to examine the pathogenicity of *Leptosphaeria biglobosa* on cultivars with good resistance (carrying the *Rlm7* gene) or moderate resistance (carrying the *Rlm4* gene) against *Leptosphaeria maculans,* causal agents of phoma stem canker on oilseed rape. Leaves with phoma leaf spots were sampled from established winter oilseed rape field trials at three representative sites in the UK. The proportions of lesions caused by *L. maculans* and *L. biglobosa* were scored on cultivars carrying the *Rlm7* gene (Excel and Roxet) or the *Rlm4* gene (Adriana and Bilbao) and the susceptible cultivar Drakkar. The proportion of *L. biglobosa* leaf spotting was greater on the cultivars that carrying *R* genes than on Drakkar. Leaf spotting caused by *L. biglobosa* was greater in the south than the north of England for all the cultivars. The aggressiveness of *L. biglobosa* isolates obtained from Excel (LbExc) and Drakkar (LbDr) was tested on Drakkar, Excel and Roxet. There was no difference between the three cultivars in aggressiveness of LbExc and LbDr. LbExc was more aggressive than LbDr on the three cultivars. These results indicate that breeding for resistance against *L. maculans* affects the susceptibility of the cultivars to *L. biglobosa.*

J Colhoun Poster

The effect of *Piriformospora indica*, an endophytic fungus, on wheat resistance to Fusarium disease

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Fusarium crown rot (FCR) is an economically important disease of wheat which occurs in most cereal producing regions of the world, reducing grain quality and yield. FCR is a soil-, seed- and stubble-borne disease and may survive several seasons in plant residues, which makes disease management difficult.

Piriformospora indica is a wide-host root endophytic fungus that belongs to the order Sebacinales (Basidiomycota). *P. indica,* like arbuscular mycorrhizal fungi, has plant growth promoting effects; in contrast, it can be cultured axenically. *P. indica* also assists in nutrient acquisition and increases tolerance to biotic and abiotic stresses. This makes it a promising candidate for biological control of plant diseases.

There is no existing published information on the effect of *P. indica* on *Fusarium* crown rot disease of wheat in UK conditions. Seedlings of wheat growing in sterilised soil-free medium were inoculated with a UK isolate of *F. culmorum* and/or *P. indica* at the time of sowing and/or seven days later, under glasshouse conditions. *F. culmorum* alone reduced emergence and led to visible browning. *P. indica* colonised roots freely in single and joint inoculations. Roots of seedlings in pots inoculated with both *F. culmorum* and *P. indica* were free of visible symptoms and emergence was normal. The concentration of *F. culmorum* DNA in roots rose rapidly in *F. culmorum*-inoculated alone. In pots co-inoculated with *P. indica, Fusarium* DNA was reduced and the relative reduction increased with time. These results suggest that *P. indica* can protect wheat seedlings from *Fusarium* crown rot damage.

J Colhoun Poster

Bacterial endophytes in wheat: isolation, community structure and *in planta* localisation

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Endophytic bacteria colonise the internal tissue of living plants for at least part of their life cycle without causing symptoms of disease. Endophytes have several functions which may directly or indirectly result in plant growth promotion through biofertilisation, biocontrol or phytostimulation. To exploit the beneficial properties of bacterial endophytes a full understanding of the factors controlling microbial community structure, their plant beneficial traits, and niche occupancy within the plant is required. We used material from the Broadbalk experimental plots at Rothamsted Research to conduct a comparative study of culturable bacterial endophyte communities in winter wheat (cv. Hereward) under contrasting fertiliser regimes. Endophyte populations were profiled using 16S rRNA gene RFLP analysis. The endophytic compartment was found to lack some key phyla found in soil, but fertiliser treatment was shown to have little effect on phylum distributions in the roots. We found greater abundance of Firmicutes and Actinobacteria in the shoots than the roots and at the genus level found limited association of specific genera to treatments. This indicates that soil is the main source of bacterial endophytes but there is a degree of endophyte adaptation and host control during colonisation. Current work aims to identify colonisation sites and niche occupancy for a selection of the endophytes. A number of these have been tagged with genes encoding fluorescent protein markers (*egfp* or *mCherry*) or the *uidA* (*gusA*) reporter. We are using epifluorescent microscopy, confocal microscopy and histochemical staining to visualise endophytes within the wheat plant tissue.

J Colhoun Poster

Biofumigation to control sclerotinia disease in vegetable crops

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The ascomycete fungus *Sclerotinia sclerotiorum* is an important necrotrophic pathogen world-wide with a host range of over 400 plant species including economically important crops such as lettuce, oilseed rape, potatoes and carrots. The pathogen survives in the soil as sclerotia which when brought close to the soil surface germinate to produce apothecia from which then ascospores are released, infecting plants upon which further sclerotia are formed and are returned to the soil.
Control methods for sclerotinia disease are predominantly through use of fungicides, and cultural practices such as deep ploughing or crop rotations. Products such as Contans WG (*Coniothyrium minitans*) and Perlka® (calcium cyanamide) can provide long-term control against the disease by reducing the viability of sclerotia in the soil, but are generally considered too costly by growers. This research looks at whether biofumigation can reduce viability of sclerotia, and hence be useful as a new control approach.
In microcosm trials the biofumigant plant *Raphanus sativus '*Terranova' reduced carpogenic germination of sclerotia by 73% in comparison to the untreated control, which compares well to the positive control Perlka® which reduced germination by 82%. Results from *in vitro* trials indicated that this reduction in germination is caused by isothiocyanates being released from the plant material. However, the low glucosinolate oilseed rape cultivar *Brassica napus* 'Temple' also reduced carpogenic germination and HPLC analysis confirmed that it does not contain significant levels of glucosinolates. This suggests that there are other volatile compounds being released from 'Temple' which affect the germination of sclerotia.

General Poster

Understanding routes of transmission as an aid to controlling *Trichoderma aggressivum* and MVX, two important compost-borne diseases of the European mushroom industry

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Mushroom virus X (MVX) and *Trichoderma aggressivum* are two compost-borne pathogens which can cause significant losses to mushroom growers. Occurrences of both diseases are sporadic and unpredictable. MushTV, an EU-funded project, aims to find technical solutions for the mushroom industry to help control these two diseases. One aspect of the project is trying to identify locations on both compost and grower facilities that may harbour infective material (inoculum). Pilot studies were conducted at both mushroom growing and mushroom compost facilities to identify potential locations for targeting in an industry-wide survey. Sample types, processing and diagnostic methods were evaluated and the most appropriate were selected for use in the industry survey. Samples were obtained from five compost facilities and fifteen grower facilities to gain information on how widespread the pathogens were and how detectable they are. It was concluded that *Trichoderma* is easily detected on facilities which had a disease problem; it was found to be widespread on such facilities, both in locations associated with cropping and in other locations. *Trichoderma* was not found on facilities with no symptoms. MVX proved to be more difficult to detect, partly due to difficulties in extracting viral material from compost -type samples. Nonetheless, MVX was also detected in samples when no symptoms were reported, making it difficult to interpret positive results. Further research is ongoing to link the diagnostics to symptoms.
This work has provided useful information for industry stakeholders on the potential for control by improved understanding of the transmissibility of pathogens.

General Poster

Responses to drought and pathogen stress are mediated by promoter activation of the barley *HvNAC6* transcription factor

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HvNAC6, a member of the plant-specific NAC transcription factor family, is known as a positive regulator of plant defence and to affect ABA accumulation in barley. However, little is known about the spatial and temporal induction of *HvNAC6* in response to abiotic and biotic stresses. Therefore, we identified and characterized the *HvNAC6* promoter. Using *in silico* analysis, we found abundant putative *cis*-acting regulatory elements in the *HvNAC6* promoter which are known to respond to abiotic and biotic stresses including ABRE, W-box, GCC box, etc. Transgenic barley plants carrying a *HvNAC6* promoter::*GUS* reporter construct were generated to study *in vivo* activation of *HvNAC6* promoter during pathogen infection and drought stress. The GUS activities were detected by fungal infection with *Blumeria graminis* f. sp. *hordei* (*Bgh*) in the vascular tissues and the epidermal cells in the leaves. During drought stress, the GUS activities were detected in the vascular tissues in both root and leaves and meristem in the lateral roots. Interestingly, the GUS activities had two distinct peaks during 30 hours after treatments, which predominantly consisted of *HvNAC6* expression. The role of *HvNAC6* in drought was further studied and we found that *HvNAC6* RNAi plants had lower relative water content (RWC) than wild-type during drought stress. This was associated with a changed expression pattern of an ABA-responsive protein kinase indicated *HvNAC6* might affect ABA accumulation in response to drought. These results imply that *HvNAC6* plays an important role in the crosstalk between abiotic and biotic stresses.

General Poster

Leptosphaeria spp., phoma stem canker and potential spread of *L. maculans* onto oilseed rape in China

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In China, the incidence of phoma stem canker observed in pre-harvest surveys from 2005 to 2012 was greater on winter oilseed rape in provinces along the Yangtze River (in May) than on spring oilseed rape in north China (in August). In all cases when the causal pathogen was isolated from stem cankers, it was identified as *Leptosphaeria biglobosa* by morphology in culture and/or by species-specific polymerase chain reaction. Both *L. biglobosa* and *L. maculans* were detected on crop debris and seed in shipments of oilseed rape seed imported into China through Shanghai or Wuhan ports in 2009–2011. Descriptions of the observed spread of *L. maculans* into areas previously colonised by *L. biglobosa* across a spring oilseed rape growing region (Alberta, Canada, westwards, 1984–1998) and across a winter oilseed rape growing region (Poland, eastwards, 1984–2004) were used to estimate the potential westward spread of *L. maculans* in China across spring oilseed rape growing regions (north China) and winter oilseed rape growing regions (provinces along the Yangtze River in central China), respectively. The rates of spread were estimated as 47 km per year across spring oilseed rape in north China and 70 km per year across winter oilseed rape in central China. Dispersal modelling suggested that the rate of spread of *L. maculans* across Alberta, Canada (*c.* 17 km per year) could be explained by wind-borne dispersal of ascospores.

General Poster

Know your enemy: insights from plant pathogenic *Streptomyces* spp. isolated in Newfoundland, Canada

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Potato common scab (CS) disease was first documented in 1825, but the causal agent remained elusive until 1890 when a bacterium, known as *Streptomyces scabies*, was isolated from scab lesions. Numerous scab-causing *Streptomyces* species have since been identified worldwide, and they differ in their susceptibility to traditional control methods. Eradication of these pathogens is further complicated by their ability to infect alternative host plants and to survive in soil in the absence of a host. As CS severely devalues the crop, consistently effective control strategies must be developed, which requires knowledge of the causal species found in potato growing regions. This study focused on characterizing the pathogenic *Streptomyces* species that cause CS on the island of Newfoundland. Five plant pathogenic *Streptomyces* species were identified following isolation from scab lesions on potatoes harvested from one location in 2011. Species identification is being undertaken through genomic fingerprinting and sequencing of housekeeping genes, with initial results showing these to be distinct from known pathogens. Further analysis revealed that the isolated pathogens lack several known virulence-associated genes and do not produce thaxtomin A. As this phytotoxin is widely regarded as essential for the development of CS, preventing its production is an attractive option for disease control. However, our study indicates that such an approach will not be universally effective against all scab-causing pathogens. Bioactivity of culture supernatants indicates production of an alternative phytotoxin, whose identity is currently being investigated. Broader characterization of isolates from different growing seasons and locations across Newfoundland is currently ongoing.

General Poster

Using quantitative resistance and *R* gene-mediated qualitative resistance for sustainable management of phoma stem canker (*Leptosphaeria maculans*) in oilseed rape (*Brassica napus*)

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Effective control of phoma stem canker (*Leptosphaeria maculans*) relies on use of host resistance. Two types of resistance to *L. maculans* have been identified: major resistance (*R*) gene-mediated qualitative resistance and quantitative resistance (QR). *R* gene-mediated resistance is race-specific and often rendered ineffective due to pathogen population changes from avirulent to virulent. QR is race non-specific and is considered durable. To investigate the interactions between *R* genes and QR, eight cultivars with different types of resistance were used in field experiments at 13 sites in the 2010/2011 and 2011/2012 growing seasons. Severity of phoma leaf spots in autumn and severity of phoma stem canker in summer were assessed. Results showed that there were effects of background quantitative resistance on the effectiveness of an *R* gene. The severity of stem canker on DK Cabernet (*Rlm1* + QR) was less than on Capitol (*Rlm1*), suggesting that *Rlm1* is more effective when it is introduced into a host background with QR than in one without QR. Less severe stem canker on Adriana (*Rlm4* + QR) than on Bilbao (*Rlm4*) suggested that *Rlm4* is more effective when it is introduced into a host background with QR than in one without QR. Interestingly, cultivars Roxet and Excel both carry *Rlm7* but Excel developed less severe phoma leaf spots and stem canker at most sites than did Roxet. It is not clear whether this was due to differences between them in host background QR because avirulent *AvrLm7* was predominant in *L. maculans* populations at UK sites.

General Poster

Molecular identification and quantification of *Leptosphaeria maculans* and *L. biglobosa* from upper stem lesions on oilseed rape cultivars with different resistance

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This project investigated the contribution of *L. biglobosa* to yield loss by comparing the ratio of *L. biglobosa* to *L. maculans* in stems with upper stem lesions or stem base cankers of winter oilseed rape cultivars with different resistance. Diseased upper stem and stem base samples were collected from nine oilseed rape cultivars in 2010/2011 and 2011/2012 field experiments at Rothamsted. The presence of *L. maculans* and *L. biglobosa* in each stem sample was detected by species-specific PCR and the abundance of two species was measured by quantifying *L. maculans* and *L. biglobosa* DNA using quantitative PCR. In 2011/2012, the frequency of *L. biglobosa* detected by PCR was greater than that of *L. maculans* in both upper stem and stem base samples. The amounts of *L. biglobosa* DNA in both upper stems and stem bases were greater than those of *L. maculans* DNA. These results suggest that the severe upper stem lesions and stem base cankers in the 2011/2012 season were mainly caused by *L. biglobosa*, suggesting that *L. biglobosa* can sometimes cause considerable yield loss in the UK. There were differences between cultivars in the amounts of *L. maculans* and *L. biglobosa* DNA. This suggests that host resistance against *L. maculans* affects the selection of the two pathogen species. The frequency and quantity of *L. biglobosa* detected in 2011/2012 were greater than those in the 2010/2011 growing season. The difference between these two seasons may have been caused by a difference in composition of the ascospore inoculum.

General Poster

Hydroxynitrile glucosides in barley and their effect on powdery mildew disease

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Barley contains five hydroxynitrile glucosides (HNGs): epiheterodendrin, epidermin, sutherlandin, osmaronin and dihydroosmaronin. HNGs are known plant defence compounds that include the cyanogenic glucosides, which can release hydrogen cyanide (epiheterodendrin is a cyanogenic glucoside). In barley, HNGs constitute more than 90% of the epidermal sugar. HNG content varies between barley cultivars, ranging from low to high. It has been suggested that increased HNG content in barley correlates with increased susceptibility to *Blumeria graminis* f. sp. *hordei*, the cause of powdery mildew (Ibenthal *et al*., 1993). However, recently we have shown that high HNG producing barley lines are more resistant to *B. graminis* infection, possibly due to the toxicity of their breakdown products, and that the compounds are induced in response to infection. To learn about the synthesis of HNGs and their importance in relation to disease susceptibility we have identified candidates for the HNG biosynthetic enzymes in barley and found that the genes are localized in two gene clusters. Transient expression of the candidate genes in tobacco results in the production of HNGs specific to barley. *In silico* expression analysis indicates that one cluster is developmentally regulated, while the other is regulated in response to biotic stress. We are also interested in the regulation of the HNG-related genes and will investigate gene expression during development and biotic stress, especially in response to *B. graminis*. Metabolite levels will be measured and correlated with gene expression to determine the regulation of HNGs in barley.

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General Poster

Can novel green manures in control replant disease on mountain ash (*Sorbus aucuparia*)?

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Specific Replant Disease (SRD) is a persistent problem that affects the propagation and cultivation of broadleaf trees, especially those being cultivated in nurseries, on a local level across the UK, and also globally. This disease is of unknown aetiology, although studies have indicated that it is caused by a build-up of an array of pathogens, which are potentially species specific. Trees particularly prone are those in the Rosaceae family. As a result the green industries face financial implications when rosaceous fruit and ornamental trees fail to produce an adequate yield or to grow to their full potential. The broad-spectrum fumigant, methyl bromide, was previously used as a treatment; however its use was revoked in 1993. With the pursuit for an alternative control measure currently being undertaken, it is proposed that the antimicrobial properties of novel green manures have the potential to treat SRD on *Sorbus aucuparia*. Current research is following a two-pronged approach, with investigations involving both microbial studies and a randomised pot trial. Results from the response of pathogens to the volatiles released from a novel green manure indicate that emissions significantly reduce the radial growth with a fungistatic rather than fungicidal outcome. Pot trials show a significant increase in the height of *S. aucuparia* in comparison to 'sick soil'. Further research will investigate changes in the microbial populations as a result of the addition of treatments will be quantified and analysed, with consideration of Microbial Inhibitory Concentrations. Pot trials will continue with measurements of growth variables completed.

General Poster

Population change of the apple scab fungus *Venturia inaequalis* in mixed cultivar orchards

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Apple scab, caused by *Venturia inaequalis,* is a major worldwide problem, and may lead to large losses of marketable fruit especially dessert apples where standards are very high. Current control is through removal of overwintering leaf litter and scheduled fungicide applications. An alternative is to deploy cultivars with varying spectrum resistance genes in mixtures to reduce scab development.

Apple orchards will stand for many years. The longer an orchard exists the more sexual reproduction in the scab population will have occurred. This recombination can potentially lead to strains that combine virulence factors to overcome the differing resistance genes in the cultivars, hence leading to the emergence of a 'super race' in the mixed orchard. The emergence and subsequent establishment/spread of super races would negate the efficacy of mixed orchards in reducing disease development.

This study aims to assess the potential risk in the emergence of 'super races' in mixture by quantifying temporal fungal population variability in mixed orchards. Isolates were collected from the different cultivars in two mixed orchards at two time points, DNA extracted and genotyped with SSR markers. These data will allow a comparison of the fungal variability among groups of isolates from different cultivars over time. If the variability among the scab populations from different cultivars reduces over time, then this would suggest that increasingly more isolates can infect more than one of the cultivars.

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General Poster

Deconstructing the polysaccharide matrix of the *Magnaporthe oryzae* cell wall

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Fungi are the most prolific, widespread and damaging agents of plant disease. Fungicides which ablate germination or germling morphogenesis and target sites absent from the host are most desirable. The fungal cell wall is thus an excellent target. Here, we describe work on the rice blast *Magnaporthe oryzae* cell wall (CW). The enzymes ß-1,3-glucan glucanosyltransferases (GSTs) are considered to split internally a ß-1,3-glucan molecule and transfer the newly generated reducing end to the non-reducing end of another ß-1,3-glucan, via a ß(1,3) linkage, so elongating the chain. There are 5 putative Glucan Elongation (Gel) proteins, carrying the Glycosyl Hydrolase 72 domain (GH72) and a putative GPI anchor. However, only two of them, Gel3 and Gel4, carry a putative Carbohydrate Binding Module (CBM43). We generated single gene knockouts (KOs) of all *M. oryzae GEL* genes and compared them with wildtype (WT) sensitivity to cell wall and plasma membrane perturbants and to oxidative stress. Reconstructing the mutant strains with fluorescently tagged proteins revealed Gel3 localises to the CW during spore development and invasion hypha growth while Gel4 showed CW localisation in spores and vegetative mycelia. Double KO *Δgel3Δgel4* does not display altered spore morphogenesis, penetration peg formation or pathogenicity in rice. Monosaccharide composition and linkage analysis of CW polysaccharides reveals only minor differences between the double KO and WT. Generating triple KO *Δgel3Δgel4Δgel1, Δgel2* or *Δgel5* and *Δgel1Δgel2Δgel5* will allow us to further evaluate loss of cell wall remodelling enzymes and wall perturbant chemistries on spore development, surface architecture, polysaccharide composition and pathogenicity.

General Poster

Novel approaches to better understand *R* gene-mediated resistance in oilseed rape

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To better understand the molecular basis of resistance of oilseed rape (*Brassica napus*) against the phoma stem canker pathogen *Leptosphaeria maculans*, the following questions are being addressed: (1) How do R proteins interact with their corresponding pathogen effectors? We are modelling the structure of leucine-rich repeat (LRR) domains of R proteins to study their interactions with effectors whose crystal structure has been solved. Accordingly, we are using genomics and bioinformatics to identify *R* gene candidates that will be exploited for protein docking models. (2) How do different *L. maculans* effectors influence plant defence responses? We are measuring the oxidative burst and defence gene expression in cotyledons of *B. napus* cultivars that are susceptible or resistant to *L. maculans* races with different combinations of effector genes. Our preliminary data suggest that *L. maculans* effectors vary in their influence on plant defence reactions. (3) What is the molecular basis of temperature-sensitivity of resistance against *L. maculans*? We have generated an antibody against LepR3, which is encoded by a recently cloned *R* gene, to determine aspects of protein stability, localization and complex formation. Pharmacological approaches will be used to address whether chaperones or protein turnover are involved in the temperature-sensitivity mechanism.

General Poster

BSPP Outreach – helping to inspire future plant doctors

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Why was BSPP Outreach set up?

BSPP Outreach was set up in October 2012 in light of a recent BSPP audit showing a major of loss of plant scientists at various UK institutes. It was decided that given the national agenda for improved food security and crop protection there needs to be an improvement in the visibility of plant pathology issues that will help to underpin teaching and research. The BSPP aims to use outreach to help promote and stimulate interest in plant pathology and consequently improve demand for studying plant pathology.

2013

Over the past year we have: developed and trialled a range of educational resources; run a 'Leafy Murder Mystery' event as part of the national Fascination of Plants day; developed and organised the 'Plant Doctor' stand at Bristol's Festival of Nature and BBC One Show Summer Festival.

2014

Next year we are planning on: expanding outreach events to various regions around the UK; developing resources for secondary and sixth form level; developing a careers resource; running the 'Plant Doctor' stand at the Big Bang Fair and attracting BSPP members and others to use resources and deliver activities.

How to get involved

There are lots of opportunities to gain experience and get involved next year. We are looking for volunteers to take part in events, use BSPP resources in schools, and write Plant Pathologist profiles. For more information, please go to: outreach.bspp.org.uk, get in touch with outreach officer Katie: outreach@bspp.org.uk and follow @BS_PP on Twitter for updates.

General Poster

Interactions between *Arabidopsis lyrata* and white blister rust caused by *Albugo candida*

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White blister rust, caused by *Albugo candida* in Brassicaceae hosts, is an excellent experimental system to investigate plant–microbe interactions. *Arabidopsis thaliana,* a selfing annual, has provided a platform for molecular dissection of host and pathogen determinants. We are extending this platform using *A. lyrata* as a closely related perennial host for comparative studies, to investigate the effects of geographic distribution and mating system in relation to white rust infections. A collection of *A. candida* isolates from wild and cultivated Brassicaceae species was used to assess phenotypic variation in North American and European collections of *A. lyrata.* The North American accessions were uniformly susceptible, whilst European accessions were uniformly resistant, to *Albugo* isolates collected in the UK from *Capsella bursa-pastoris.* Two *Albugo* isolates collected from *Arabidopsis* were virulent in a low frequency of the European accessions, indicating that natural variation occurs in the pathogen to overcome rust resistance in this host population. Both collections of *A. lyrata* exhibited a high frequency of resistance to Canadian isolates of *Albugo*, collected from *B. rapa* and *B. juncea.* This suggests that European *A. lyrata* are better adapted to an environment where *Albugo* inoculum is prevalent from related host species. F_1 hybrids between a susceptible North American accession and several resistant European accessions were all highly susceptible under epidemic conditions, indicating recessive resistance and no selective advantage of heterozygosity. We are currently using ITS markers and developing new markers to differentiate variants of *Albugo* that infect cultivated and wild Brassicaceae including *A. lyrata*.

General Poster

Characterization of Egyptian *Botrytis cinerea* isolates from different host plants

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Grey mould causes considerable economic losses of fruit and vegetable production. The current study on Egyptian population structure of *B. cinerea*, the causal pathogen of grey mould, provided a new finding that this species is composed of four sympatric species, *transposa*, *vacuma*, *Boty* type and *Flipper* type using transposable elements and sensitivity to the hydroxyanilide fungicide fenhexamid for 33 isolates collected from grape, strawberry, and lettuce in Egypt. Among 33 isolates tested, 21 had two transposable elements, *Boty* and *Flipper* (*transposa* type), 7 had only the *Boty* element (*Boty* type), 3 had only the *Flipper* element (*Flipper* type) and 2 had neither of these elements (*vacuma* type). These isolates showed resistance variation to fenhexamid. Moreover, *B. cinerea* strains isolated from different host plants did not exhibit any host preference using an artificial infection test. Preliminary molecular analysis demonstrated no relationship between strain type and aggressiveness.

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2014 BSPP Presidential Meeting
1st and 2nd September

The Gateway, The University of St Andrews

"Some like it hot"

Lesley Torrance,
President-elect

Global warming will affect disease incidence, the emergence of new strains and effectiveness of control measures. To safeguard food production it is vital to develop stress resilient crops and ensure agricultural practices employ the most efficient technologies. This meeting will focus on current advances in basic plant pathology research that will contribute to sustainable crop production in a warming world. It will comprise invited keynote presentations and offered papers on how abiotic stress affects:

(i) the molecular mechanisms of disease resistance and susceptibility,
(ii) forecasting the incidence and emergence of new strains, and
(iii) how control measures can be devised, improved and adapted to meet the challenge.

Perspectives from developed and developing world farming systems will be considered.

British Society for Plant Pathology
BSPP