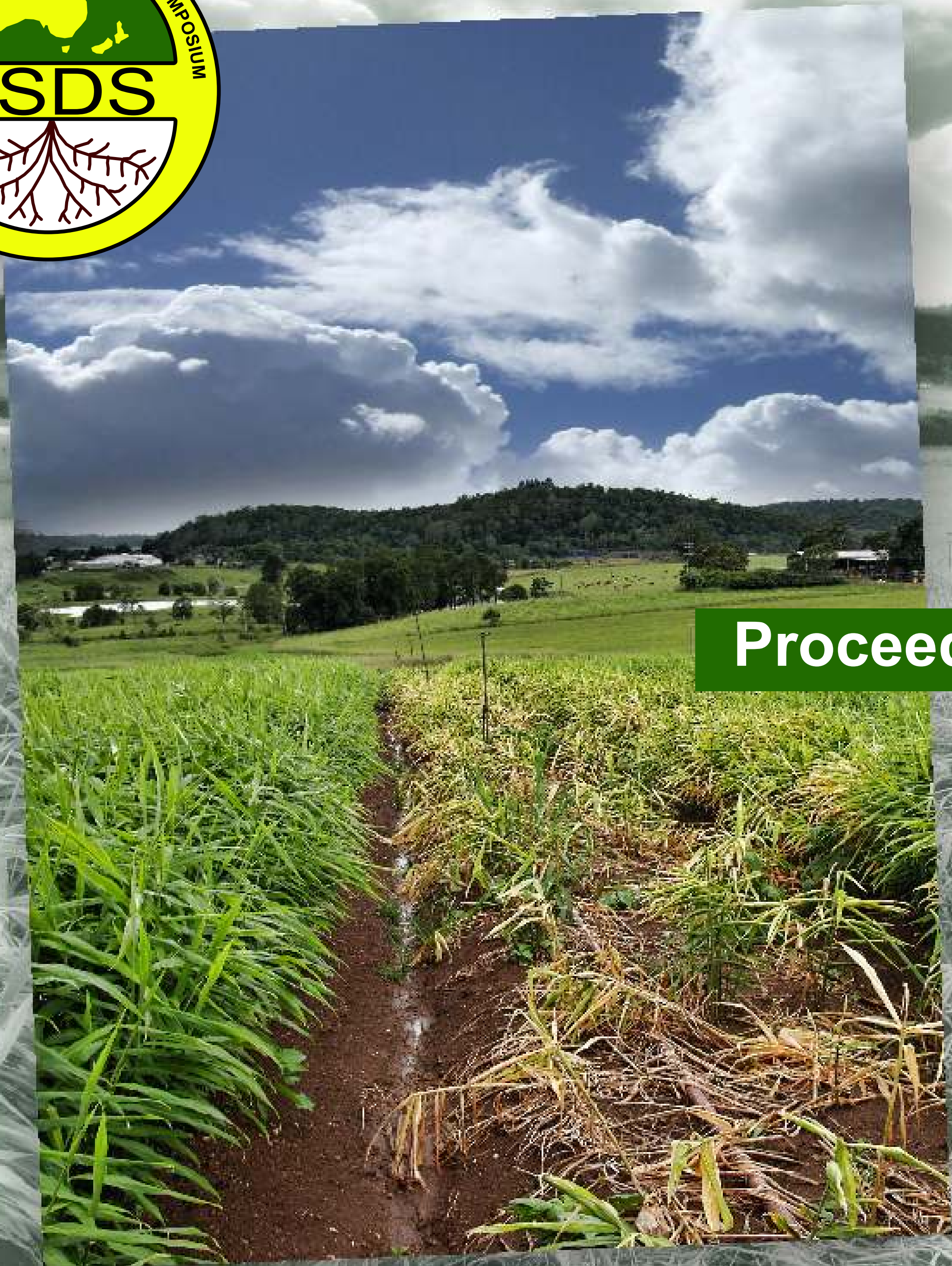
6th Australasian **Soilborne Diseases** Symposium

Twin Waters, Queensland
9–11 August 2010



Proceedings

ORAL AND POSTER PRESENTATIONS

KEYNOTE SPEAKERS

UNDERSTANDING SOIL PROCESSES: ONE OF THE LAST FRONTIERS IN BIOLOGICAL AND ECOLOGICAL RESEARCH

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Soils are one of the great unknown realms on earth, despite decades of extensive research. We still see soils 'through a ped darkly' (Coleman 1985). This opacity in milieu and understanding rewards innovative study, however, as soils are 'complex adaptive systems' (Young and Crawford 2004; Crawford *et al.* 2005), with sophisticated levels of self-organization.

Viewed historically, soil ecological studies have progressed from what major groups of biota are present, what is their biomass, and what major processes occur. More recent studies have delineated multi-trophic interactions, extending both above- and below-ground, as well as specifically-targeted studies of substrates and organisms that are involved in the development and function of suppressive soils. One of the great unknowns in soil ecology is a fuller understanding of the complete array of predatory biota. Soils are teeming with organisms in all three Domains, but are also rife with many phages and other viruses infecting Archaea and Eukarya. Pursuing a more holistic approach including viral biology and ecology may enable us to more capably manage our soils that have supported the biosphere so much over the millennia.

Looking into the future, the opportunity to exploit soil biodiversity in the context of ecosystem development should pay considerable dividends. Following the fungal: bacterial ratios in ecosystem successions, sensu Harris (2009) deserves further exploration. Metatranscriptomics, i.e., the measurement of genomes that are active at any point in time, should be explored by soil ecologists. Using chronosequence analysis, the relationships between soil biodiversity and ecosystem function are beginning to be understood. Finally, management of the plant-soil-microbial-faunal food web via various organic amendments shows possibilities in the study and management of suppressive soils. I look forward to stimulating presentations on these topics during the meeting.

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RISKS AND BENEFITS OF USING COMPOSTS AS ORGANIC SOIL AMENDMENTS

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The supply of composts has increased in many countries due to the enforced diversion from landfill of organic biodegradable wastes. These include green wastes such as yard trimmings and reject fruit and vegetables, carbon-rich materials such as paper and wood wastes, nitrogenous wastes such as animal manures and sewage sludge, and increasing quantities of food wastes. Often the primary financial incentive for composting is for this organic waste disposal, with income from low value end-products such as organic soil amendments being a secondary or negligible consideration. Composts can have a significant agricultural benefit, particularly on impoverished soils, in regions with limited rainfall, and in organic agriculture, where the use of synthetic fertilisers is not permitted. These benefits include the supply of plant nutrients, particularly P and K, increased soil organic matter, moisture retention, and cation exchange capacity, improved soil structure, and suppression of soil-borne diseases and weeds. However, the bulkiness of compost means that transport for use as an organic soil amendment is usually only viable over short distances. Regulations such as the EU nitrates directive (Anon, 1991) can limit permitted compost application rates to below those which result in significant benefit, at least in the short term. The use of composts can also pose risks such as those caused by contents of toxic elements and compounds such as herbicide residues, populations of plant and animal pathogens which may have survived the composting process, and man-made inerts such as glass and plastic (Noble *et al*., 2009). Composts may contain high levels of soluble salts or be too alkaline or immature, leading to the immobilisation of soil nitrogen and/or phytotoxicity caused by organic acids and other volatile organic compounds. Compost variability can also be a significant problem, leading to unpredictable crop response. This variability can be measurable such as nutrient content and salinity, but the causes and measurement of compost variability in relation to factors such as nitrogen supply and immobilisation, and disease suppressiveness may be elusive (Noble and Coventry, 2005). Greater control over variables in the composting process, such as in the selection and rejection of feedstock wastes, moisture content adjustment and in allowing for an adequate maturation period, can improve compost quality and uniformity although cost implications must also be considered if compost use as a soil organic amendment is to be viable. The introduction of compost quality standards such as PAS 100 in the UK (Anon., 2005) has been aimed at reducing risks to the compost end user and improving confidence in compost use. Composts can be incorporated into the soil profile or used as a surface mulch. Often the best methods and timing of compost application in the field have yet to be established for particular crops, cropping rotations, soil types, and locations.

Research at Warwick HRI has focused on reducing the risks posed by the plant pathogen content of composts, and improving the understanding, efficacy and reliability of disease suppression resulting from soil amendment with composts. The temperature and exposure time in compost required for eradicating a range of plant pathogens with hardy resting spores such as *Plasmodiophora brassicae* and *Fusarium oxysporum* formae speciales, or sclerotia such as *Sclerotinia sclerotiorum* and *Sclerotium cepivorum* has been established in both controlled laboratory and large-scale composting tests. The development of indicator organisms which can be inserted in compost and tested for subsequent viability has been used to augment time-temperature data for testing the sanitisation of composting wastes.

The suppression of soil-borne pathogens has frequently been shown to be due to microbial antagonism by demonstration of loss of suppressiveness following compost sterilisation (Noble and Coventry, 2005). However, abiotic factors such as increases in soil pH following compost amendment have also been correlated with control of wilt diseases caused by *F. oxysporum* and clubroot of Brassicas caused by *P. brassicae* (Termorshuizen *et al*, 2007; Noble *et al*., 2006). Composted onion waste, a significant disposal problem for the onion industry, has been shown to retain the onion volatiles that stimulate the germination and subsequent death of resting sclerotia of the Allium white rot pathogen, *S. cepivorum,* before an onion crop is planted in infested soil. A significant problem in the biological control of soil-pathogens in the field has been the achievement of sufficiently high soil populations of biocontrol agents at an economically viable cost. Composts that support the growth of biocontrol agents such as *Trichoderma viride* have been used to increase the soil population of these beneficial microorganisms to levels which give reproducible levels of control of both Allium white rot (Coventry *et al*., 2006) and Fusarium basal rot caused by *F. oxysporum* f.sp. *cepae*.

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NEW TECHNOLOGIES TO BETTER UNDERSTAND ECOLOGICAL PROCESSES AND COMMUNITY DYNAMICS

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Advances in 'Omics' technologies is giving unprecedented insight into the biological world, and has been particularly impactful for microbial ecology since for the first time we can have a more comprehensive view of community structure, gene composition and at least some information on activity through expressed proteins and metabolic fluxes. These advances have been driven by advances in sequencing technologies, which have increased the capacity and lowered the cost, i.e. the democratisation of sequencing. A decade ago we were analysing Kb of sequence, a few years ago Mb, now Gb, and next year perhaps Tb. The problem has become how to analyse such massive data sets, not its generation. It is also changing the expertise needed for microbial ecology to one in which coding, computation, high throughput pipelines, and visualization tools are the daily activity. Nonetheless, the biological insight and questions must remain front and centre so that the most important knowledge is gained from the new technologies.

In microbial ecology we can now use these technologies to do certain things well. We can more comprehensively determine community structure to much greater depth and replication, and use that information to assess community differences over time and space, and correlate those differences with environmental attributes. We can also learn about the types and amounts of genes associated with key functions in communities by amplicon (gene-targeted) pyrosequencing (Iwai et. al., 2009) or microarray (GeoChip) technologies (He et. al., 2007). These are particularly useful for genes directly involved in biogeochemical cycles, cell signalling, pathogenicity, antibiotic resistance and biodegradation, for example, and will at some future period allow sequences to be diagnostic markers for ecologically important functions. Shotgun metagenomics, first used in marine microbial ecology, but now beginning to be used productively in soil (the most complex habitat) provides the catalogue for all genes in a community, some of which will reflect the selection that led to their occurrence. The current challenge for using metagenomics in soil is that its complexity makes it difficult to obtain sufficient assembly to interpret function. Deeper sequencing with the more advanced sequencing methods is beginning to make some progress on this key front. The deeper sequencing is also providing improved insight into expression using RNASeq, an approach we used with a bacterial culture under soil-inducing conditions (Yoder-Himes).

I will illustrate the uses and understanding gained from these methods in several studies including the rhizospheres of different crops, the effect of land-use change, and the effect of different ecosystems on the composition of targeted functional genes and taxa.

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Agri-Science Queensland at the Department of Employment, Economic Development and Innovation works to ensure the economic and environmental sustainability of Queensland's primary industries. Our skilled staff create innovative solutions to pest and disease management through world-leading science and by working with industry to implement effective application of practices.
The Plant Science and Horticulture and Forestry Science groups are investigating management of soil borne diseases in winter cereals, summer field crops and horticultural crops.
Some of the key research areas include developing germplasm with enhanced resistance to crown rot and root lesion nematodes of wheat, investigating reduction of *Fusarium oxysporum* in cotton by rotational cropping sequences, developing rapid screening for resistance to white mould and black rot in peanuts and management of Phytophthora root rot in avocado and pineapple via selection of resistant varieties, and optimising traditional treatments.
For more information on Agri-Science Queensland and our work in soil borne diseases, visit www.deedi.qld.gov.au or call 13 25 23.

PROCEEDINGS OF THE SIXTH AUSTRALASIAN SOILBORNE DISEASES SYMPOSIUM

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Cover photograph
Pythium myriotylum causing rhizome rot of ginger at Eumundi, about 20 km from the conference venue

Welcome to the Sixth Australasian Soilborne Diseases Symposium

Two features of modern science are its fragmentation into disciplines and a necessity to specialise. Thus even in areas as specific as soilborne diseases, scientists tend to see themselves as plant pathologists, mycologists, nematologists, microbiologists, soil ecologists or molecular biologists. Also, knowledge is often limited to a few pathogens on one or two crops.

Although some specialisation is necessary if we are to continue to improve our understanding of the complex belowground world, those working on soilborne diseases cannot afford to ignore the broader picture. We may be working on one specific aspect of a problem, but we need to recognise that numerous pathogens and a myriad of competitors interact within the root zone and these interactions are influenced by many factors, including moisture, temperature and the soil's physical and chemical environment. We also need to recognise that our current cropping systems are the result of years of research and numerous inputs from growers, so new and potentially useful management practices must pass the test of being practical, profitable and sustainable.

The purpose of this meeting is to encourage interaction between scientists with disparate skills but a common interest in soil biology and soilborne diseases. The expertise of participants covers a wide range of fields, so please take the opportunity to discuss your work with as many of our delegates as possible. Hopefully you will leave with many new ideas and some collaborative arrangements that will add value to your research and extension programs.

Enjoy your three days at Twin Waters!

Graham Stirling
Chair, Organising Committee, 6ASDS

Organising committee
Dr Graham Stirling, Biological Crop Protection, Moggill
Ms Jenny Cobon, Agri-Science Queensland, Indooroopilly
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PROGRAM

Time	Topic	Speaker	Page number
Monday 9 August			
1000 1045	Registration and morning tea sponsored by CRDC Opening of symposium		
Session 1 1100	Chair: Graham Stirling ***Biological interactions in soil*** • Understanding soil processes: one of the last frontiers in biological and ecological research	David Coleman	1
1200	Lunch		
Session 2 1300 1400	Chair: Kathy Ophel-Keller ***New insights into the structure and function of microbial communities*** • New technologies to better understand ecological processes and community dynamics • Potential applications of soil microbial metagenomics	James Tiedje Pauline Mele	4 15
1430	Afternoon tea		
Session 3 1500	***Poster session***		
1730	Welcome reception and dinner		
Tuesday 10 August			
Session 4 0900 0930 0950 1010	Chair: Matthew Cromey ***Restoration of organic carbon in soil*** • Risks and benefits of using compost as organic soil amendments • Microbial sequestration of organic carbon • Potential for biochar in soilborne disease management • Importance of soil organic matter to soil health and disease suppression in vegetable crops	Ralph Noble Peter McGee Lukas Van Zweiten Ian Porter	2 10 25 20
1030	Morning tea sponsored by SRDC		
Session 5 1100 1115 1130 1145 1200 1215	Chair: Olufemi Akinsanmi ***Contributed paper session 1*** • Characterisation of *Rhizoctonia solani* anastomosis group 2-1 from potato tubers in New Zealand • Genetic diversity of *Plasmodiophora brassicae* in Australia • Progress in comparing *Fusarium pseudograminearum* infection levels and crown rot symptoms in stem internodes of cereals • Does addition of the element silicon affect the infection process of *Fusarium oxysporum* f. sp. *cubense* on banana? • Response of soil microfloral communities to stubble addition differs between suppressive and non-suppressive soils • Identifying QTL for Fusarium crown rot resistance (*F. graminearum*) in two spring wheat populations (Sunco/Macon and Sunco/Otis)	Subha Das Abdelwahab Badi Jill Petrisko Kevan Jones Vadakattu Gupta Grant Poole	41 32 74 58 50 76
1230	Lunch		

Session 6 1330 1400 1430	Chair: Grant Hollaway ***Options for enhancing resistance to soilborne diseases of cereals*** • A commercial breeder's perspective • A plant pathologist's perspective • An international perspective on breeding for resistance to soilborne pathogens	 Russell Eastwood Hugh Wallwork Richard Trethowan	 8 27 24
1500	Afternoon tea		
Session 7 1530 1630 1640-1700	Chair: Jason Sheedy ***The role of vegetable farming systems in disease management*** • Sustainable farming systems- key management factors and their application to subtropical and tropical vegetable production systems • Sustainability in temperate vegetable production • General discussion	 Mike Bell, Stephen Harper, Tony Pattison Ian Porter, Richard Falloon	 5 77
1830	Symposium dinner		
Wednesday 11 August			
Session 8 0900 0915 0930 0945 1000 1015	Chair: Alison Stewart ***Contributed paper session 2*** • 2,4- Dichlorophenoxyacetic acid induced resistance to common scab of potato • Are organic farming soils more disease suppressive? • A descriptive model for improved management of crown rot of wheat • Quantifying tuber- and soil-borne inoculum of *Rhizoctonia solani* in potato production systems in New Zealand • The potential of biofumigant and green manure crops as a tool to manage soilborne diseases in vegetable crops • Management of *Phytophthora cinnamomi* in Australian avocado orchards	 Hannah Thompson Leanne Forsyth David Backhouse Shirley Thompson Caroline Donald Luke Smith	 96 47 30 99 43 86
1030	Morning tea		
Session 9 1100 1130 1200	Chair: Richard Falloon ***Diagnosis and prediction in relation to soilborne diseases*** • New approaches for detecting *Phytophthora* • Use of molecular diagnostics for improved decision making by growers ***Soil biology in the Australian grains industry*** • Harnessing the biological potential of Australia's grain growing soils	 Philip O'Brien Alan McKay Pauline Mele	 19 11 13
1230	Lunch		
Session 10 1330 1400 1430	Chair: Kirsty Owen ***Biological control of soilborne pathogens*** • Understanding variability in biocontrol systems • Using composts to suppress soilborne diseases ***International cereal research*** • International research and capacity building for control of soilborne pathogens in rainfed wheat	 Alison Stewart Ralph Noble Julie Nicol	 22 2 17
1500	Business session (arrangements for ASDS7)		
1510	Afternoon tea and finish		

The future of the Australasian Soilborne Diseases Symposium (ASDS)

The first ASDS was held in February 1999 on the Gold Coast (Queensland) and was followed by meetings in Lorne (Victoria), the Barossa Valley (South Australia), Queenstown (New Zealand) and Thredbo (New South Wales). These symposia have proved to be a valuable forum for those interested in soil health, soilborne diseases and soil biology. Our delegates have come from many countries and have worked on a wide range of crops, pathogens and beneficial organisms in diverse environments. Some have been experts in specific areas such as soil ecology and molecular biology while others have had a broader role in agronomy, extension, teaching or the commercial aspects of agriculture. In an era where science is becoming increasingly specialised, this interaction between people with different skills and backgrounds has contributed to the success of ASDS.

Previous arrangements for organizing ASDS have been quite informal, and we would like to see it remain that way. Although we don't have a constitution or a management committee, the current system has worked well, as we have always been able to find a group of people prepared to organise the next symposium. This has allowed flexibility in the choice of meeting location, content of the scientific program and meeting theme, and ensured that ASDS has continued to evolve and remain relevant.

Since the meeting in Thredbo 18 months ago, we have made the following arrangements in the hope that they will make it easier to organise future symposia:

- ASDS is now a formal sub-group within the Australasian Plant Pathology Society (APPS). This ensures that ASDS has access to the APPS website and can readily communicate with the wider plant pathology community, both in Australasia and elsewhere
- Arrangements have been made to deposit any profits from symposia in an APPS account. Not only will this provide accountability, but it will ensure that start-up funds are available to the organising committee of the next ASDS.
- ASDS keynote papers have always been published in Australasian Plant Pathology, but the issue of whether ASDS is liable for page charges has never been fully clarified. Arrangements have now been made to ensure that our keynote papers are treated in the same way as keynote papers at APPS conferences
- Within three months of the completion of 6ASDS, the current organising committee will report on the meeting, provide a profit/loss statement and summarise the results of a questionnaire completed by delegates. We hope that future committees will see such reporting as a worthwhile endeavour, as it should assist those planning the next symposium

We hope that these arrangements will help ensure that ASDS has a long term future and that it remains relevant to all those interested in soilborne pathogens and the complex world they inhabit.

Graham Stirling and Rob Magarey

Australasian Soilborne Diseases Symposium
Keynote papers

Abstracts of keynote papers are presented in these Proceedings.
Complete versions of these papers will be published in Australasian Plant Pathology (volume 40, first issue of 2011)

Biographical sketches of keynote speakers

David Coleman is Distinguished Research Professor Emeritus, University of Georgia, Athens, Georgia, USA. David obtained his PhD from the University of Oregon and after five years at the University of Georgia, moved to the University of Colorado at Fort Collins. During his time in Colorado (1972-1985) David played a key role in perhaps the world's most influential soil ecology group, contributing to our understanding of biotic interactions in the rhizosphere; food web structure and function; organic matter decomposition and turnover; and nutrient dynamics in soil. On his return to the University of Georgia in 1985, he continued his research on energetics, decomposition, nutrient cycling and soil biodiversity. In 1996 he co-authored *Fundamentals of Soil Ecology*, which became an important reference text for scientists and students with an interest in soil biology and ecology. In 1979-80 he was Senior Research Fellow with the Soil Bureau at Lower Hutt, New Zealand, and in 2006, a McMaster Visiting Fellow with CSIRO in Adelaide, South Australia.

James Tiedje is Distinguished Professor of Microbiology and Molecular Genetics Michigan State University, East Lansing, Michigan, USA. After degrees from Iowa State University and Cornell University, James' research has focused on microbial ecology, physiology and diversity, especially with regard to the nitrogen cycle, biodegradation of environmental pollutants and the use of molecular and genomic approaches to understand microbial community function. He was Editor of *Applied and Environmental Microbiology* and *Microbial and Molecular Biology Reviews*, served on the National Research Council's Board on Life Sciences and Co-Chaired a Committee on the new science of Metagenomics. James was President of the American Society for Microbiology and the International Society of Microbial Ecology and is a member of the U.S. National Academy of Sciences. He shared the 1992 Finley Prize from UNESCO for research contributions in microbiology of international significance and was recently awarded an Einstein Professorship by the Chinese Academy of Sciences.

Ralph Noble is Professor and Principal Investigator at Warwick HRI (formerly Horticultural Research International but now part of the University of Warwick) in Wellesbourne, UK. He obtained his BSc from the University of Reading and a PhD from Cranfield University. After a short period of postdoctoral research at the Institut für Landtechnik at Bonn University, Germany, Ralph has worked in applied crop research in the UK since 1984. He was previously based at HRI Littelehampton and has been at Wellesbourne since 1994. His main research interests are: suppressing plant pathogens using composts; control of soil-borne plant pathogens using biocontrol agents; examining the survival of plant pathogens during composting; recycling wastes to produce peat-free horticultural growing media; reducing composting odours; and mushroom cultivation. He has been involved in horticultural research and development projects in several countries in Europe, as well as the USA, Mauritius, China, New Zealand and Australia.

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