Biennial Report

Forestry & Agricultural Biotechnology Institute

May 2013 - May 2015

The Forestry and Agricultural Biotechnology Institute (FABI) is located on the campus of the University of Pretoria. The primary objectives of the Institute are to:

- Promote the broad field of plant biotechnology through an interdisciplinary approach and with close linkage to a wide range of academic departments.
- Undertake research of the highest possible calibre, while at the same time providing short and longer term benefits to the forestry and agricultural sectors of South Africa.
- Establish partnerships with industries linked to agriculture and forestry, both nationally and internationally, to produce new and improved products and thus to promote competitiveness in trading.
- Promote the education, particularly of South Africans, in the fields of forestry and agriculture.

The association of FABI with the University of Pretoria, the largest residential University in South Africa, provides access to a wide range of human and technological resources. Currently, academic staff and postgraduate students from research programmes in the Departments of Biochemistry, Genetics, Microbiology and Plant Pathology, Plant Production, Plant Sciences and Zoology and Entomology are associated with FABI. This affords FABI the opportunity to build future resources in biotechnology which will be crucial to the future of forestry and agriculture in South Africa.

FABI, in every way, represents an amalgamation of a tremendous base of expertise in forestry and agriculture from different universities and research organisations in South Africa and other countries through our collaborations. The Institute has been operational since 1998. This document represents the fifth FABI biennial report covering the period from May 2013 to May 2015.

FORESTRY AND AGRICULTURAL BIOTECHNOLOGY INSTITUTE (FABI)

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Forestry and Agricultural Biotechnology Institute

FUTURE FORESTS and *FOOD*

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FABI TEAM

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2nd Row

Mingliang Lin, Brittany Mitchell, Andy Wilson, Vou Moses Shutt, Gloria Mukwirimba, Felix Fru, Phathie Sibanda, Grieta Mahlangu, Ilkadim Kapir, Ashok Prabhu, David Nsibo, Palesa Madupe, Kay Bophela, Wilhelm de Beer, Dusan Sabikovic, Irene Barnes, Louise Shuey.

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Gudrun Dittrich-Schröder, Morné Booij-Liewes, Danielle Roodt, Osmond Mlonyeni, Noëlani van den Berg, Juanita Engelbrecht, Angelica Marsberg-de Villiers, Simone Fouche, Melissa Simpson, Angie du Preez, Annie Chan, Ronishree Mangwanda, Katrin Fitza, Steven Hussey, Margot Muller, Lizahn Zwart, Lizel Potgieter.

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DIRECTOR'S REPORT

At the start of 1997, FABI was simply an idea in the minds of a small number of people. Six months later, serious physical construction was underway and remarkably, by the end of that year, the first of the FABI team members were at the University of Pretoria, working in beautifully refurbished laboratories. And just six months later, now 17 years ago, the research facility that we now refer to as FABI MAIN BUILDING was ready to be occupied. Much "water has passed under the FABI bridge" since that time. The FABI Square/Bioinformatics building was completed in 2005 and very substantial infrastructure was constructed on the University Research "Farm" site. But let me not focus on the physical facilities. While important and as impressive as they are, they are but a mere shell. It is the FABI team members that make the Institute so remarkable. If you have not visited us, please do so. And as a "sweetener" follow our activities on the FABI website www.fabinet.up.ac.za.

In just 17 years FABI has reached the position of having a very significant national as well as international "footprint". The Institute incorporates the research programmes of 25 academic staff who publish under the FABI address together with a team of approximately 140 M.Sc. and Ph.D. students, Post Doctoral Researchers and Research Fellows. A relatively small but agile team of administrative and technical staff supports this group. Students in FABI form a remarkable international community with around 30 mother tongue languages spoken in the Institute. When, as it often happens, I am asked to explain the rapid growth and success of FABI, my first thought is that it is the cultural and social diversity of the team that have made us what we are. Of course there is much more that underpins a successful research undertaking than our diversity. But it is the FABI PEOPLE that make us what we are and in this regard FABI represents a truly astonishing team of superb and committed people.

The two years that have passed since our last Biennial Report have been filled with many great accomplishments. These are far more numerous than I could possibly (or should attempt to) highlight individually. But you will see in this summary report, a scattering of examples of awards won by FABI team members, degrees earned and various other aspects of our research output. FABI has, in every way, performed superbly and its position as a leading research entity of the University of Pretoria is well deserved. I am particularly proud of the fact that almost all of the FABI leadership team have achieved National Research Foundation 'ratings' with ratings including two A's, eight B's, four C's and eight Y's. As will be well understood locally, this is an exceptional achievement for any South African research team and, as I track our progress, I am convinced that these ratings will continue to rise.

Successful research depends deeply on funding. As is true at all Universities, financial support is earned mainly from research grants and contracts. The University of Pretoria provides generous support for staff salaries, some infrastructure and access to various student-funding streams. But FABI relies heavily on financial support from the agricultural and forestry industries of South Africa (and beyond) as well as from various national and international funding bodies. Maintaining and growing this support requires huge effort on the part of the FABI leadership who have shown that, often under difficult circumstances and in a financially stressed environment, it is possible to leverage support for high quality research. I take this opportunity to thank the many funding bodies and sponsors (listed in this document) for their support without which FABI would not excel as it does.

This Biennial Report includes summaries of the activities of the major research groups in FABI. While these illustrate the diversity of our research activities, they are far from comprehensive. But I do hope that they will give you some idea of the work we do. FABI is a vibrant and very energetic environment. While our focus is on research excellence and in serving the requirements of our stakeholders, we are also very conscious of the role that we must play in community activities, mentorship and in the upliftment of those less fortunate than we are. Elements of these activities will be clear in this report. Alongside these various activities we enjoy ourselves as I am sure will be clear from illustrations of some of our social engagements.

FABI is flying and flying high! This would not be possible without the support of a superb Advisory Committee, the Management Committee of FABI who lead our activities and of course the entire and exceptional FABI TEAM. It remains a privilege for me to lead this amazing group and I do so with great enjoyment and appreciation. I hope that you will find this report interesting and informative. As I pointed out at the start of this message, I hope you will follow our activities and visit us when you can.

Mike Wingfield Ph.D. (Minnesota), FRSSA, ASSAf
Mondi Professor of Forest Pathology
Director of FABI, the Tree Protection Co-operative Programme (TPCP) &
The DST-NRF Centre of Excellence in Tree Health Biotechnology (CTHB)

RESEARCH REPORTS

BACTERIAL GENOMICS AND TREE HEALTH

Research leader: Prof. Fanus Venter

Research team: Dr. Martin Coetzee
Prof. Teresa Coutinho
Prof. Emma Steenkamp
Dr. Pieter de Maayer

OBJECTIVES OF THE RESEARCH PROGRAMME:

Genomics forms an integral part of many studies in microbiology as it provides an opportunity to expand our knowledge and understanding of an organism's biology. With the help of genome sequencing and comparisons, various questions related to the evolution of plant-associated bacteria can be addressed. This information is essential for the development of strategies to predict and control future disease outbreaks associated with these pathogens or could be used to exploit symbiotic relationships to improve plant health.

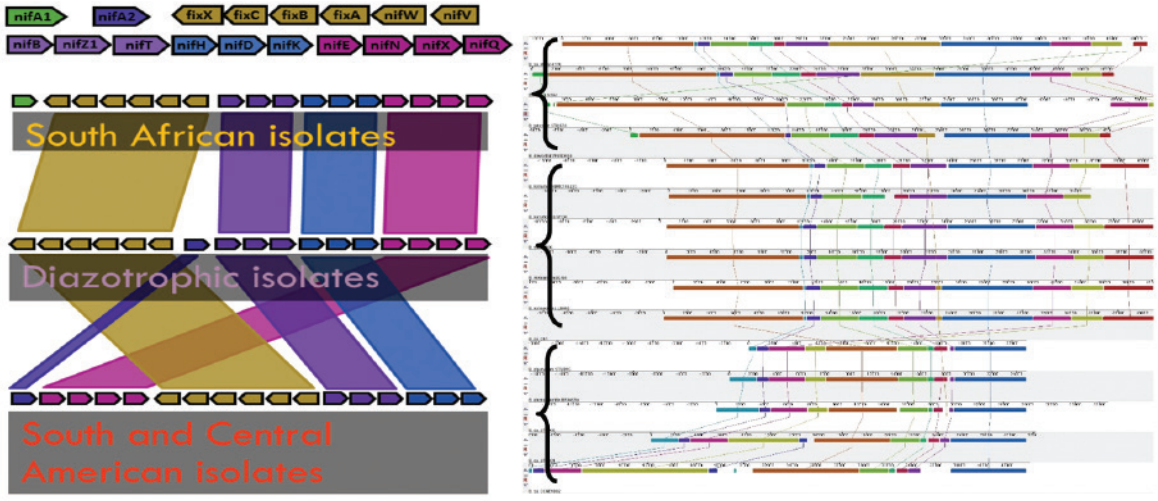
In our research programme, bacterial genomics is used to gain insight into the pathogenicity of tree pathogens such as members of the genera *Pantoea*, *Ralstonia* and *Xanthomonas*. Phylogenomics is used to reconstruct the evolution of the genus Pantoea in order to understand how members of this genus have evolved to be pathogenic to both plants and animals. The genomes of strains representing the different species of *Pantoea* were also used to validate genomic approaches for the delineation of species in this genus. Comparative genomics is also used to study the evolution of nitrogen fixation in *Burkholderia* species nodulating trees such as *Virgilia*, and other plant hosts endemic to South Africa. These findings shed light on how this interaction could be used to the benefit of the plant host and what role the bacteria play in the ecosystem.

RESEARCH HIGHLIGHTS:

- Comparisons of the genomes of several *Pantoea ananatis* strains revealed that this species has an 'open' pan-genome typical of bacterial species that colonise several different environments. The pan-genome incorporates a large number of genes encoding proteins that may enable *P. ananatis* to colonise, persist in and potentially cause disease symptoms in a wide range of plant and animal hosts.

- A database of nearly 40 genomes representing 19 validly described *Pantoea* species has been compiled. The core genes shared amongst the different species have been identified for a sub-set of these genomes and have been used for the construction of a reliable phylogenetic tree to study the evolution of the genus *Pantoea*.

- Genome comparisons revealed three distinct structures for the nitrogen fixation loci of selected *Burkholderia* species. Each structure could be clearly linked to either the South African rhizobia, the general diazotrophs or the rhizobial species from other parts of the world. Phylogenetic analyses of these nitrogen fixation genes suggested distinct evolutionary origins for the three types of nitrogen fixation loci associated with the genus *Burkholderia*.



Nif locus comparison of 15 *Burkholderia* strains representing South African symbionts, non-South African symbionts and diazotrophics strains.

DST-NRF CENTRE OF EXCELLENCE IN TREE HEALTH BIOTECHNOLOGY (CTHB)

Director: Prof. Mike Wingfield

Deputy Director and Programme Manager: Prof. Emma Steenkamp

Project leaders:
Prof. Nigel Barker (RU)
Prof. Teresa Coutinho (UP)
Prof. Pedro Crous (UP & CBS, the Netherlands)
Prof. Jo Dames (RU)
Prof. Deanne Drake (WITS)
Prof. Leanne Dreyer (US)
Prof. Gert Marais (UFS)
Prof. Gerhard Pietersen (UP & ARC)
Prof. Jolanda Roux (UP)
Prof. Thomas Seifert (US)
Prof. Bernard Slippers (UP)
Prof. Noëlani van den Berg (UP)
Prof. Brenda Wingfield (UP)
Prof. Edward Witkowski (WITS)
Dr. Irene Barnes (UP)
Dr. Martin Coetzee (UP)
Dr. Wilhelm de Beer (UP)
Dr. Jeff Garnas (UP)
Dr. Marieka Gryzenhout (UFS)
Dr. Eastonce Gwata (UV)
Dr. Brett Hurley (UP)
Dr. Ednah Kunjeku (UV)
Dr. Francois Roets (US)
Dr. Wayne Twine (WITS)
Dr. Alex Valentine (US)
Dr. Albé van der Merwe (UP)

OBJECTIVES OF THE RESEARCH PROGRAMME:

The primary goal of the CTHB is to promote the health of trees native to South Africa through the application of biotechnology tools. To achieve this goal, the CTHB team typically studies the pathogens and pests that are associated with native trees and other woody plants. Members of the Centre also explore the possible effects that factors such as climate change, fire, genetic diversity and human activity may have on the health of native woody resources and ecosystems.

The CTHB is hosted by the Forestry and Agricultural Biotechnology Institute (FABI) at the University of Pretoria (UP). The CTHB is structured as a virtual Centre of Excellence that conducts research via a collaborative network of scientists, with the central node of the network represented by researchers at UP. In addition to the UP group, the network includes researchers and their postgraduate students at many other institutions in South Africa. Since 2011, these included the Agricultural Research Council (ARC), Rhodes University (RU), and the Universities of Stellenbosch (US), the Witwatersrand (WITS), the Free State (UFS) and Venda (UV).

The research projects of the CTHB are typically focused on the following:

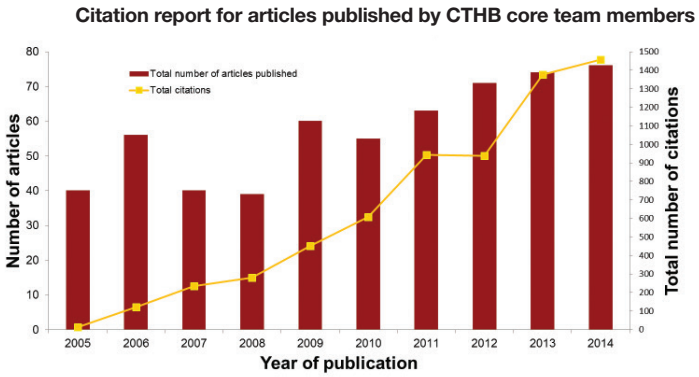
- The biology, ecology, genetics, population biology and systematics of insects and microbes associated with native woody plants.
- The biology and ecology of specific tree species, as well as the effect that human practices might have on these species, the ecosystems in which they occur and the conservation of natural habitats.
- The possible impacts of soil properties and nutrients, microbial symbioses and climatic factors on the health of woody plants in diverse landscapes.
- The effects of drought, frost, fire and human activity on the sustainable use of indigenous woody resources.

Most of the work focusing on insects and microbes associated with native woody plants is conducted at the University of Pretoria. Projects studying the effects of environmental and anthropogenic factors on the health of native woody hosts and natural habitats are mostly conducted at the other

institutions. The CTHB, together with the Tree Protection Co-operative Programme (TPCP), annually produces a large number of research papers (see the figure right) of which more than 40 typically deal specifically with health issues of indigenous trees.

As a successful Centre of Excellence, the CTHB is involved in various activities that either inform its research or that emanate from the previous research of the Centre. For example, the CTHB routinely conducts surveys and field experiments in various parts of South Africa and elsewhere on the continent. Together with its partner programme, the TPCP, the CTHB also maintains a world-class disease and insect pest diagnostic clinic. To facilitate and enhance the research and extension activities of the CTHB, the Centre has developed and implemented a number of ancillary processes. These include various databases and collections to manage and store information, data and biological material used in projects.

The CTHB is actively involved in outreach initiatives aimed at promoting a robust and skilled South African human resource base. For this purpose a formal mentorship programme is used to specifically target undergraduate students. The CTHB is also involved in a number of initiatives aimed at improving the public's understanding of Science and providing high school learners with information about post-secondary education opportunities in the natural sciences.



Citation report for articles published in international peer-review journals by researchers of the CTHB from 2005 to 2015. The data for this report were obtained using the Thomson Reuters Web of Knowledge[SM] (accessed 20 March 2015), which was also used to generate the citation statistics. Note that these data only include the papers produced by the members of the CTHB at UP, and not those produced by members of the extended programme at other Universities and at the ARC. During this analysis, the value for the H-Index of the Centre's publications was 36 according to Thomson Reuters Web of Knowledge[SM] (20 March 2015).

Advisory Committee of the DST-NRF Centre of Excellence in Tree Health Biotechnology (CTHB) at their meeting in May 2015

From left to right: Prof. Mike Wingfield (Director: CTHB), Prof. Diana Six (College of Forestry and Conservation, University of Montana, USA), Prof. Coert Geldenhuys (Extraordinary Professor – Forest Ecology, University of Stellenbosch), Prof. Emma Steenkamp (Deputy Director and Programme Manager: CTHB), Mr. Mike Edwards (ex Managing Director: Forestry South Africa), Prof. Jean Lubuma (Dean: Faculty of Natural and Agricultural Sciences, University of Pretoria), Prof. Stephanie Burton (Vice-Principal: University of Pretoria), Dr. Thandi Mgwebi (Executive Director: Institutional Engagement and Partnership Development, National Research Foundation), Prof. Urmilla Bob (Environmental Sciences, University of Kwazulu-Natal), Prof. Eddie Mwenje (Vice Chancellor: Bindura University of Science Education), Mr. Frank Mazibuko (National Research Foundation), Dr. Wessel Vermeulen (Knysna, South African National Parks).

CERC/FABI *EUCALYPTUS* PROTECTION PROGRAMME (CFEPP)

Research leader: Dr. ShuaiFei Chen

Research team: Prof. Jolanda Roux
Prof. Mike Wingfield
Prof. Teresa Coutinho
Prof. YaoJian Xie (CERC, China)
Dr. Roger Arnold (CERC, China)
Dr. Wilhelm de Beer
Mr. GuoQing Li (CERC, China)

OBJECTIVES OF THE RESEARCH PROGRAMME:

- Study the genetic diversity and biology of pathogens and pests threatening plantation development in South China.
- Understand the interactions between pathogens/ insects and hosts, and screen plantation forestry hybrids for tolerant to the most important pathogens.
- Train young researchers working on tree health, share research results between the China Eucalypt Research Centre (CERC) and FABI, and establish a model for cooperation between South Africa and China.

RESEARCH HIGHLIGHTS:

Eucalypt diseases

The sustainable development of plantations is under increasing threat due to pathogens. The CERC/FABI *Eucalyptus* Protection Programme (CFEPP) is devoted to understanding the distribution, genetic diversity and biology of the important pathogens. We focus on several important plantation diseases including plantation stem canker caused by Botryosphaeriaceae (conducted by Mr. GuoQing Li), wilt caused by species of *Ceratocystis* (conducted by Ms. FeiFei Liu), tree leaf blight and seedling rot caused by species of *Calonectria* (conducted by Ms. JieQiong Li and Ms. QianLi Liu), and bacterial wilt caused by *Ralstonia solanacearum* (conducted by Ms. Gabrielle Carstensen).

Eucalypt pests

The most important pests which cause severe destruction in *Eucalyptus* plantations in China include the defoliator *Buzura supressaria*, the wood borer *Endoclita signifier* and the gall wasp *Leptocybe invasa*. CFEPP conducted extensive surveys to understand the geographic distribution and the damage characteristics of these insect pests. This information will help to develop management strategies for insect pest control.

Bark beetle-fungi interactions

CFEPP conducts research to understand the taxonomy and biology of Ophiostomatalian fungi with specific reference to associates of conifer-infesting bark beetles. Our work focuses on the species in the genera *Ips* and *Tomicus*, and their fungal associates in the genera *Ophiostoma, Grosmannia*, and *Leptographium*. A large number of conifer-infesting bark beetles and their galleries have been collected from provinces of JiangXi, QingHai (research conducted by Mr. MingLiang Yin), YunNan and HeiLongJiang (conducted by Mr. RunLei Chang).

The CFEPP team collecting *Eucalyptus* leaf blight materials caused by species of *Calonectria* in South China.

FeiFei Liu, Gabrielle Carstensen, Dr. ShuaiFei Chen, Prof. Jolanda Roux and GuoQing Li.

CEREAL FOLIAR PATHOGEN RESEARCH PROGRAMME

Research leader: Dr. Bridget Crampton

Collaborators/ Team Members: Prof. Dave Berger (University of Pretoria)
Dr. Irene Barnes (University of Pretoria)
Dr. Maryke Craven (ARC Grain Crops Institute)
Dr. Shane Murray (University of Cape Town)

OBJECTIVES OF THE RESEARCH PROGRAMME:

Research projects within the Cereal Foliar Pathogen Research (CFPR) Group are currently focused on two fungal pathogens. *Cercospora zeina* causes grey leaf spot (GLS) of maize in South Africa, and *Exserohilum turcicum* is the causal agent of northern corn leaf blight in maize, sorghum and related grass species. We are interested in characterising fungal pathogenicity factors responsible for disease in plants as well as examining the cereal plants' molecular response to infection by these Dothideomycete pathogens.

RESEARCH HIGHLIGHTS:

Grey leaf spot disease of maize

Grey leaf spot (GLS) disease, caused by *Cercospora zeina*, results in millions of Rands worth of loss to maize fields every year. The CFPR group, in collaboration with Prof. Dave Berger, has focused their research on the identification and functional characterisation of *C. zeina* pathogenicity factors. In this regard, we used a draft genome sequence of *C. zeina* to identify and annotate genes of interest. The well characterised Dothideomycete effectors *Avr4*, *ecp2* and *ecp6* genes were found to be expressed by *C. zeina* following *in planta* infection of maize. In addition, the pathogenicity factor genes *czk3* and *crp1*, previously characterised in the sibling species *C. zeae-maydis*, were also expressed in *C. zeina* during maize infection. However, while gene knockout studies suggested that *crp1* plays a similar role in *C. zeina* as in *C. zeae-maydis* in terms of maize stomatal perception and appresorium formation, *C. zeina Δczk3* gene knockouts showed that this gene is not involved in inhibiting conidia formation as it is in *C. zeae-maydis*.

Northern corn leaf blight

Northern Corn Leaf Blight (NCLB) is a destructive foliar disease of maize that results in yield losses worldwide. In South Africa, typical yield losses range from 15-30%. In order to better understand the population structure of *E. turcicum* in South African maize and sorghum fields, we collected NCLB lesions from locations around South Africa, performed single spore isolations of *E. turcicum*, and genotyped these using fourteen polymorphic microsatellite markers developed to the *Setosphaeria turcica* genome sequence. In addition to this, we developed mating type specific PCR markers to *E. turcicum* to determine the mating type of isolates. Results showed no distinct genetic clusters of *E. turcicum* isolates, and shared haplotypes were observed between isolates in different geographical maize growing regions. In addition, mating type distributions revealed little evidence of sexual recombination. Thus the population genetic structure of *E. turcicum* in maize is likely due to the direct movement and spread of isolates and a predominantly asexual reproduction cycle. Interestingly, *E. turcicum* isolates from sorghum clustered separately from maize isolates, and were not able to infect maize differential set lines. We are therefore undertaking a follow-up study to assess the genotypes of sorghum *E. turcicum* isolates to determine if they are genetically distinct from maize isolates. Initial results suggest that some sorghum *E. turcicum* isolates are genotypically similar to maize isolates from the same field, whilst others group separately and appear genetically distinct.

The CFPR group has recently been awarded two grants to characterise the maize-*E. turcicum* and sorghum-*E. turcicum* pathosystems. In this regard, we have inoculated NCLB susceptible maize plants with two different races of *E. turcicum* and performed RNA-seq studies to identify *E. turcicum* pathogenicity factors and characterise the maize transcriptional response to the pathogen. Similar studies are now being undertaken in sorghum with a sorghum specific *E. turcicum* isolate.

Alandie Nieuwoudt, Brigitte Langenhoven and Miekie Haasbroek collecting NCLB lesions from maize plants.

NCLB on (A) maize and (B) sorghum leaves. NCLB lesions on sorghum leaves are characterised by tannin accumulation around the edges of the lesions.

DIVERSITY AND EVOLUTION OF RHIZOBIA ASSOCIATED WITH NATIVE WOODY LEGUMES

Research leader: Prof. Emma Steenkamp

Research team: Prof. Fanus Venter
Dr. Elritha van Zyl
Prof. Thomaz Stepkowski (Poland)

OBJECTIVES OF THE RESEARCH PROGRAMME:

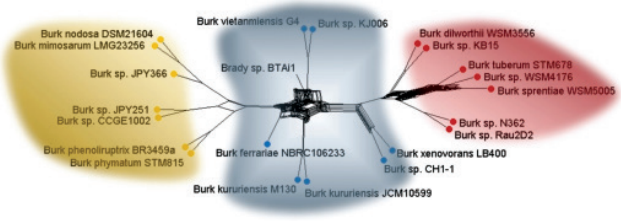
South Africa is remarkably rich in legumes that, through their symbiosis with rhizobia, contribute significantly to biological nitrogen-fixation and ultimately ecosystem health. The rhizobia associated with non-native agricultural legumes are relatively well-studied, but little is known about those associated with the majority of native South African leguminous woody plants. Our overall research goals are are therefore to (i) characterise and describe the rhizobia associated with native legume species, (ii) reconstruct the evolutionary history (iii) and infer the phylo- and biogeography of these to bacteria. Ultimately, comparisons with the findings of similar studies on legumes from other parts of the world and with those conducted on non-native agricultural crops will provide valuable insight into the possible forces determining the biogeography and ecology of these bacteria.

RESEARCH HIGHLIGHTS:

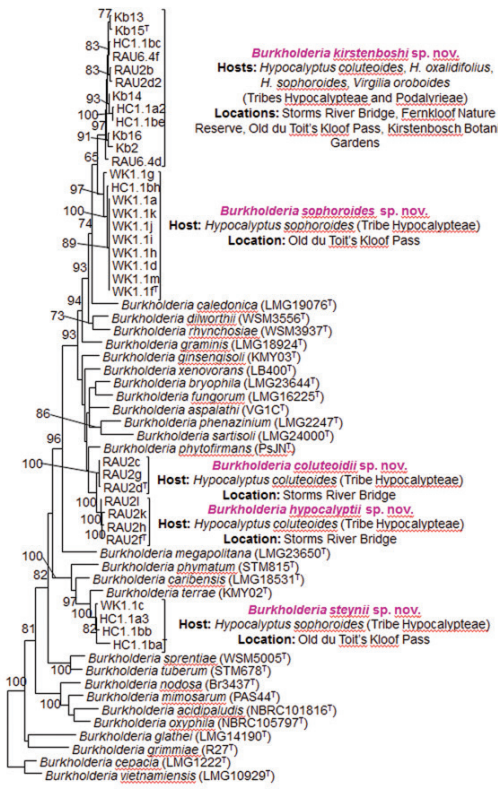
- The diversity of the rhizobia native to South Africa appears to match those of their legume hosts. During 2013-2014, we focused on formal description of the rhizobia representing distinct lineages that had been previously isolated from the root nodules of various hosts in the tribes Podalyrieae, Hypocalyptieae, Crotalarieae and Genisteae. Manuscripts providing formal names to five of these (i.e., *Burkholderia kirstenboschi*, *B. sophoroidus*, *B. coluteoidii*, *B. hypocalyptiia* and *B. steynii*) are currently in review.

- Genomics is a major field of research that impacts all fundamental and applied research on bacteria, especially those capable of establishing of nitrogen-fixing symbioses with legumes. Apart from the various rhizobial genomes being sequenced at FABI, our collaboration with workers overseas has also lead to the 2014 initiation of a further 28 genome sequencing projects through the Joint Genome Institute of the US Department of Energy. Access to these genomic resources will be invaluable for all future explorations in rhizobiology.

- With the genome data currently available, we have investigated the evolution of the genetic locus responsible for nitrogen fixation in *Burkholderia*. These analyses showed that the locus of South African rhizobial species all share the same basic structure that was markedly different from those of non-South African rhizobial species and free-living diazotrophs. Phylogenetic analyses also suggested a distinct evolutionary origin for this group. Overall, these data indicated that horizontal gene transfer, gene rearrangement and/or gene replacement contributed to some of the differences observed in the architecture of the nitrogen fixation loci within the genus *Burkholderia*.



Relationships among rhizobial and free-living diazotrophic *Burkholderia* species. The image depicts a super network tree where the South African rhizobial isolates, diazotrophic and non-South African rhizobial isolates are indicated in red, blue and yellow, respectively.



A phylogenetic tree depicting the relationships of our newly delineated and characterised species of indigenous *Burkholderia* (indicated with square brackets and in pink boldface) with one another and the known species of this genus. The tribal membership of their legume hosts and their geographic origins are also shown. The numbers at the various nodes indicate percentage bootstrap support and the strain numbers of the reference species are indicated in parentheses.

EUCALYPTUS AND PINE PATHOGEN INTERACTIONS (EPPI)

Research leader: Dr. Sanushka Naidoo

Research team: Prof. Dave Berger
Prof. Zander Myburg
Prof. Bernard Slippers
Prof. Emma Steenkamp
Dr. Albé van der Merwe

OBJECTIVES OF THE RESEARCH PROGRAMME:

The *Eucalyptus* and Pine Interactions (EPPI) group works closely with the Forest Molecular Genetics (FMG) programme and the Tree Protection Co-operative Programme (TPCP) to understand the defence response of *Eucalyptus* and *Pinus* spp. to pests and pathogens. *Eucalyptus* species, hybrids and clones encounter an array of pests and pathogens that threaten the Eucalypt industry. As an example, the gall wasp, *Leptocybe invasa* (Fisher and La Salle) has emerged as one of the most important insect pests worldwide, causing galling on leaf midribs, shoot-tips and petioles resulting in stunting and death in severe cases. Other pathogens, such as the fungal pathogen *Chrysoporthe austroafricana*, and the root rot pathogen *Phytophthora cinnamomi,* are concomitant with *Eucalyptus* plantation forests. Recently, the fungus *Puccinia psidii* (Myrtle rust) has become a concern to SA forestry as the pathogen has been detected on related Myrtaceae locally. The fungal pathogen *Fusarium circinatum* remains a major limiting factor to the production of *Pinus patula* in South Africa, manifesting as a nursery disease or as pitch canker disease in older trees. The EPPI research is targeted at obtaining a comprehensive understanding of the plant defence mechanisms that are involved in resistance in these forest species. This complex aim is achieved by utilising a functional genomics approach and use of genomic resources for *Eucalyptus grandis* and *Pinus patula*. It is envisioned that knowledge of these forest tree defence mechanisms could be harnessed to develop genotypes with enhanced resistance via breeding programmes or genetic manipulation in future.

HIGHLIGHTS OF OUR RESEARCH:

The *E. grandis* genome shows a high rate of tandem duplication, which has led to domain expansions of genes related to innate immunity. This provides an important resource to understand plant defence mechanisms. Based on the genome sequence, we determined the complement of pathogenesis related genes in *E. grandis* in comparison to *Arabidopsis* and *Populus*. We compiled a review of these findings in "Uncovering the defence responses in *Eucalyptus* against pests and pathogens in the genomics age" in Tree Physiology (Naidoo *et al*. 2014). Over the past two years we have established a comprehensive transcriptome of *E. grandis* under various biotic stress challenges. These include challenges with *Leptocybe invasa*, *Chrysoporthe austroafricana*, and *Phytophthora cinnamomi*. We have recently extended this to include the *Eucalyptus-Puccinia psidii* interaction, together with collaborators in Queensland, Australia and Post-Doctoral researcher Dr. Louise Shuey.

We observed changes in the terpene profiles of resistant and susceptible genotypes of *E. grandis* during the *C. austroafricana* challenge (Visser *et al.* 2015) and showed distinct responses in the resistant and susceptible genotypes of *E. grandis*, involving various defence systems including hormone differences (Mangwanda *et al*. 2015). A suppression of gibberellic acid levels in the moderately resistant host was observed which we hypothesise to be important for successful defence against the pathogen.

(L-R) Dr. Louise Shuey, Dr. Carsten Kulheim (Australian National University), Lizahn Zwart, Mmoledi Mphahlele, Erik Visser, Jane Bredenkamp, Ronishree Mangwanda and Dr. Sanushka Naidoo on a field trip to collect *Eucalyptus grandis* leaf samples, challenged with *Leptocybe invasa*, for secondary metabolite analysis.

We are extending our research in the *Eucalyptus-Chrysoporthe austroafricana* interaction to study pathogen ingress, colonisation and host histochemical changes in mildly resistant and susceptible genotypes. Ms. Lizahn Zwart is completing this aspect of the research. In addition, together with our collaborator, Dr. Albé van der Merwe (TPCP), we are exploring the pathogen responses *in planta* during inoculation. Ms. Ronishree Mangwanda has sequenced the transcriptome of the pathogen, providing insight into cause and effect of the defence responses seen in the host.

Our research into the *Eucalyptus-Leptocybe invasa* interaction has revealed distinct secondary metabolite (terpenoid profiles) for the resistant and susceptible genotypes, which we are further exploring as important determinants for resistance against the insect pest (Oates *et al.* 2015). Based on these results, Ms. Caryn Oates is characterising host responses during gall development both microscopically and transcriptomically and aims to develop a systems biology model of the interaction.

Based on the *E. grandis* biotic challenge datasets obtained to date, we are able to perform a meta-analysis to identify core defence responses in *E. grandis* to diverse perturbations and signature defence mechanisms to each of them. In this manner, we are identifying candidate genes for functional genetic characterisation in the model system, *Arabidopsis thaliana*, before prioritising candidates to be investigated in *E. grandis*. Ms. Jane Bredenkamp is leading the functional genetics characterisation of candidate defence genes.

Until recently, genomic resources for pine species lagged behind that of *Eucalyptus*. The *Pinus taeda* genome sequence has recently been released and in an exciting recent development, Mr. Erik Visser has generated a transcriptome assembly for *P. patula*. This is the first genomic resource for the species which will provide a platform to model the defence response to *F. circinatum* and allow for the development of markers for pine breeding in future.

These research initiatives are culminating in progress towards the understanding of defence responses in forest trees. This will translate into applicable outputs for forest management of pests and pathogens in future, as part of an integrated approach.

FOREST MOLECULAR GENETICS (FMG) PROGRAMME:

Genomics and Biotechnology for Superior Wood and Fibre

Research leader: Prof. Zander Myburg

Research team: Mr. Eshchar Mizrachi
Dr. Sanushka Naidoo
Dr. Steven Hussey
Dr. Nanette Christie

OBJECTIVES OF THE RESEARCH PROGRAMME:

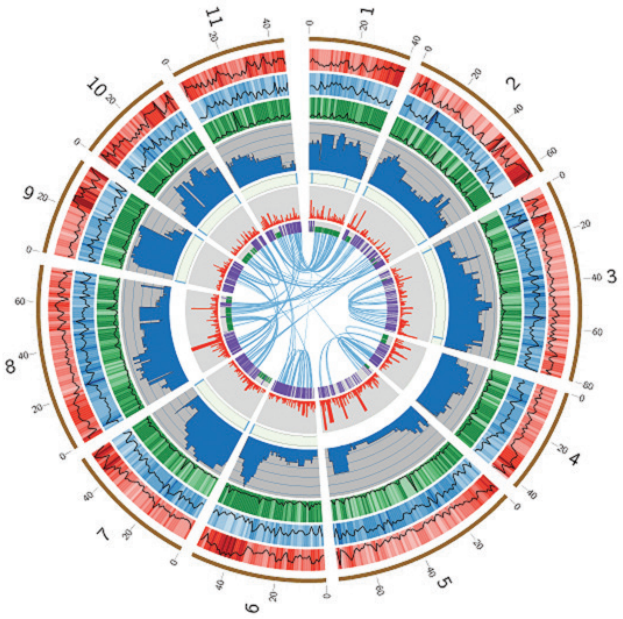
The Forest Molecular Genetics (FMG) Programme focuses on the genetic control of growth and development in fast-growing plantation trees with a view to develop biotechnology applications to enhance biomass production and improve wood properties for timber, pulp, paper, and other bio-based products. Concomitant with this, we aim to understand molecular mechanisms involved in pest and disease resistance in trees for woody biomass protection (see *Eucalyptus* and Pine Pathogen Interactions - EPPI Group pages elsewhere in this report). We work in close collaboration with South African forestry companies through the FMG Consortium to develop human capacity and resources for the application of biotechnology in tree improvement programmes.

HIGHLIGHTS OF OUR RESEARCH:

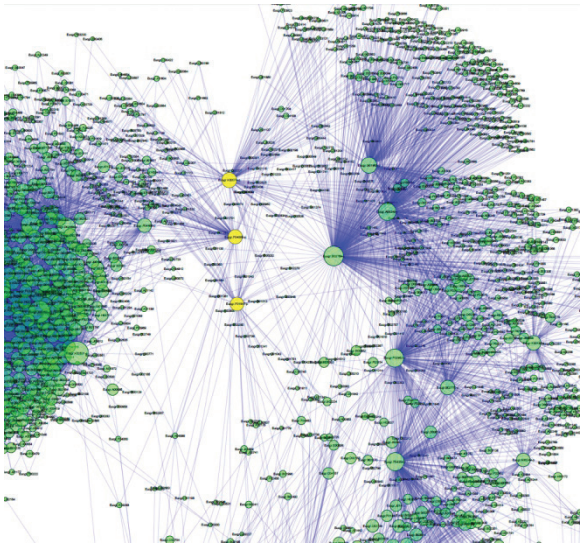
A major milestone for our research programme in the past two years was the completion and publication of the *Eucalyptus grandis* genome sequence (Myburg *et al.* 2014). This has provided access to the entire molecular blueprint underlying tree growth, development, reproduction and defence. We collaborated with researchers from over 30 international institutions to uncover key aspects of the unique biology of *Eucalyptus* trees including genome evolution, woody biomass production, transcriptional control, carbohydrate and secondary metabolism and reproductive biology. The genome sequence has also served as a valuable reference for the development of a genome-wide DNA marker resource for *Eucalyptus*, which we are deploying for genomic breeding and selection in two large pilot projects in *E. grandis* and *E. dunnii* initiated with our industrial partners in the past two years. Another major genomic resource generated in the past two years is a whole-transcriptome assembly for *Pinus patula* (see EPPI Group pages), which will allow us to develop similar genomic breeding resources for tropical pine species and hybrids grown in South Africa. Other research highlights are detailed below:

Modelling wood formation:

A single developing wood fibre cell is a busy place. Like a bustling metropolis, the cell must manage limited resources between various locations to ensure proper maintenance, growth, and output, while cooperating with neighbouring cells and the extracellular environment. Sugars and sugar nucleotides (activated sugars) are



Genome overview of *Eucalyptus grandis* showing gene density, expression, heterozygosity and diversity



Eucalyptus xylem gene expression network

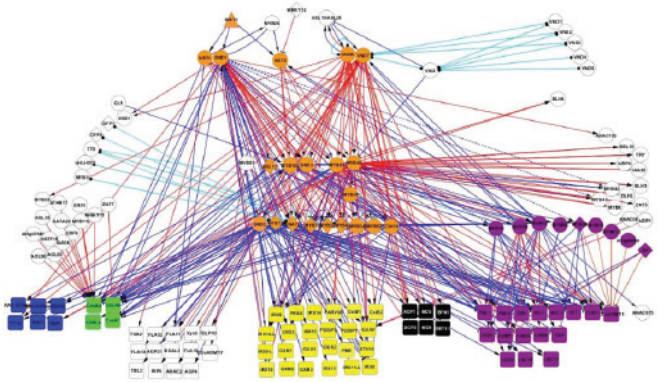
constantly in flux – being stored, converted, polymerised and broken down according to the needs of the cell. During secondary cell wall deposition the primary sinks for the cell's imported carbon are cellulose, xylan and lignin. In research led by Dr. Eshchar Mizrachi we have been pursuing questions around the management of carbon and factors determining its allocation to these biopolymers. In the past two years we have applied genomics and bioinformatics tools to molecular data (expressed genes and metabolites in developing wood and other tree tissues/organs) to study changes in carbon allocation in field-grown *Eucalyptus* trees - for example in response to bending stress and tension wood formation (Mizrachi *et al.*, 2015). This allowed us to address specific questions on how carbohydrate metabolism may impact these processes (Pinard *et al.*, 2015), how it may have evolved in vascular plants (Kersting *et al.*, 2015; Vanneste *et al.*, 2015) and how the wood development programme compares with that of other trees such as *Populus* (Hefer *et al.*, 2015). We have also applied these approaches (transcriptome and metabolome profiling) across tree populations (see Population Genomics section below), and related this back to variation in complex traits such as growth and cell wall properties (*Mizrachi et al.* unpublished). Applying this *systems genetics* approach allows us to recognise which genes and pathways influence complex phenotypes in field-grown forest trees.

Transcriptional and epigenomic regulation of wood development:

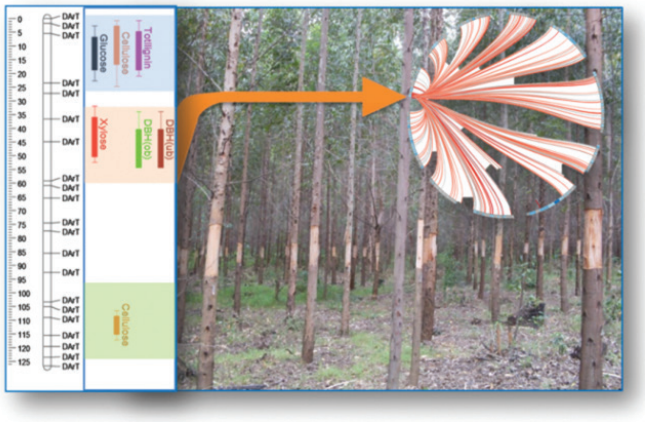
Wood development, and secondary cell wall formation in particular, is subject to strong transcriptional regulation mediated by a complex network of interacting transcription factors (Hussey *et al.* 2013). Epigenomic control such as that mediated by chromatin modifications are also known to play important roles in plant development and are likely also involved in wood development. The *E. grandis* genome sequence has allowed us to start identifying the corresponding molecular components of the transcriptional and epigenomic machinery of *Eucalyptus*. For example, we have been able to identify the orthologs of MYB (Soler *et al.* 2014) and NAC (Hussey *et al.* 2014) transcription factor families that are key regulators of secondary cell wall biosynthesis in plants. In research led by Dr. Steven Hussey we have started using genomics-oriented approaches such as chromatin immuno-precipitation sequencing (ChIP-seq) analysis and RNA-seq expression profiling to unravel the functions of transcription factors and histone (chromatin) modifications involved in wood development in *Eucalyptus* (Hussey *et al.* 2015).

Population genomics and molecular breeding:

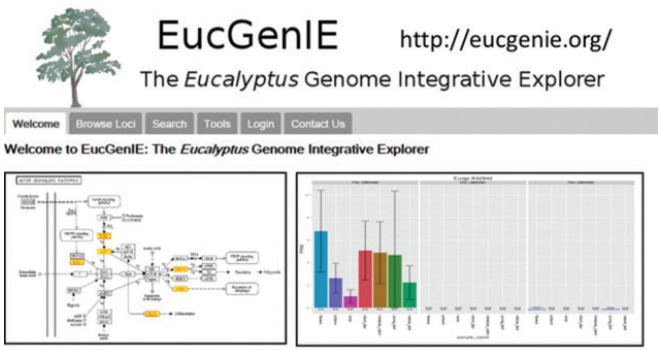
Genetic correlation among growth and wood properties, and component traits such as gene expression and metabolite profiles segregating in tree populations, provides a powerful framework for genetic dissection of biological systems (i.e. *systems genetics*). The *E. grandis* genome sequence can now be used as reference for detecting and studying genetic variation affecting these traits. In the past two years we have expanded our work on interspecific backcross populations of *E. grandis* x *E. urophylla* and mapped genomic regions affecting gene expression, metabolite abundance and a wide range of growth, wood chemistry and bioenergy traits in hybrid progeny sampled at three, six and eight years (Mbanjo, Christie, Myburg, in preparation). Along with international collaborators, we have also started exploring genomic diversity across *Eucalyptus* species (Hudson *et al.* 2015) and we have analysed breeding trials using a newly developed DNA marker resource for *Eucalyptus* with 60,000 SNP markers. We have initiated two pilot genomic selection trials in *E. grandis* and *E. dunnii* with our industry partners, Sappi and Mondi. These experimental populations will be used for genome-wide association studies of growth and wood properties, as well as pest and disease resistance in research led by Dr. Sanushka Naidoo in collaboration with the Tree Protection Co-operative Programme (See EPPI and TPCP pages).



Transcriptional network regulating secondary cell wall biopolymer synthesis (from Hussey *et al.* 2013)



Genome mapping of wood properties and gene expression in tree populations



Bioinformatics and statistical genomics:

We have generated more than 400 whole-transcriptome (RNA-seq) profiles for *Eucalyptus* trees. To make this data accessible to our own group and the wider scientific community (post publication) we have developed an online bioinformatics resource, the *Eucalyptus* Genome Integrative Explorer (EucGenie), which features interactive tools to explore gene expression patterns and pathways across developmental stages, organs and external pertubations such as tension wood formation and pest and disease responses. In work led by Dr. Nanette Christie, we have also developed bioinformatics pipelines for high-throughput statistical analysis of large genomics datasets such as gene expression mapping in tree populations.

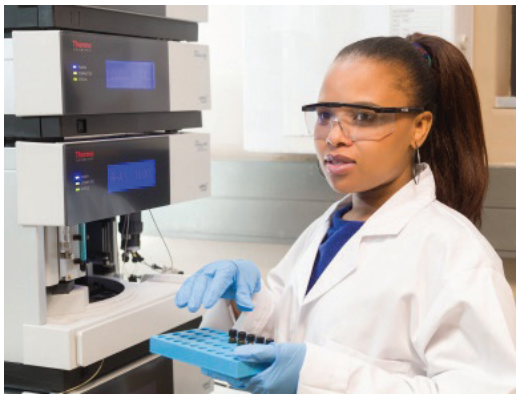
Functional genetic testing wood formation genes:

Our functional genomics and systems genetics research is creating hypotheses about candidate genes that are targets for biotechnology (Mewalal *et al.*, 2014). In the past two years, we have used transgenic *Arabidopsis* and *Populus* plants to test candidate genes and strategies such as tissue-specific expression to engineer fibre cell wall traits. We plan to expand this work to transgenic *Eucalyptus* trees in the next two years. This work guides rational biotechnology approaches for improving wood and opens up new avenues to beneficiate downstream processing and novel products in the bioeconomy (Mir *et al.*, 2014).

Technology platforms:

Besides the Bioinformatics Platform and Tissue Culture and Transformation Platforms mentioned above, we have further expanded our Wood Chemistry Platform to include Klason lignin and HPLC cell wall sugar analysis, as well as α-cellulose and S:G lignin monomer composition. Our DNA Marker Anlysis Platform offers DNA fingerprinting, parentage analysis and species identification of *Eucalyptus* and pine trees accessible to members of the FMG Consortium and other forestry companies in South Africa.

Testing fibre cell wall genes in *Arabidopsis* plants



Wood chemistry analysis

Forest Molecular Genetics Team 2014

FRUIT TREE BIOTECHNOLOGY PROGRAMME

Research leader: Dr Noëlani van den Berg

Collaborators: Prof. Dave Berger
Prof. Teresa Coutinho
Dr. Bridget Crampton
Dr. Enrique Ibarra-Laclette
Dr. Sanushka Naidoo
Dr. Nicolette Taylor

OBJECTIVES OF THE RESEARCH PROGRAMME:

The Fruit Tree Biotechnology Programme (FTBP) aims to understand the defence response of avocado to the oomycete pathogen *Phytophthora cinnamomi*, the causal agent of Phytophthora root rot (PRR). In addition, the response of avocado to abiotic stresses such as salinity and flooding are also studied within the group due to their impact on industry. FTBP constitutes a collaborative research effort between the Hans Merensky Foundation, Westfalia Technological Services, and the University of Pretoria in order to address problems confronting the avocado industry, particularly investigating the performance of various rootstocks tolerant to PRR. Knowledge gained from these studies will aid in the development of molecular tools for improvement of rootstocks. Some of the objectives include:

- Discovery of genes important in defence and abiotic stress response.
- Elucidation of the metabolic pathways and regulatory networks important in response to these stresses.
- Functional validation of these genes.
- Generation of genomic resources such as transcriptome and proteome data.
- Development and establishment of an efficient transformation system for *P. cinnamomi.*
- Development of tools that can be used to aid conventional rootstock selection and breeding.

RESEARCH HIGHLIGHTS:

Avocado sequence resources

A root transcriptome was sequenced and assembled within the group. Data from this study was utilised to design a microarray for large-scale gene expression analysis. Several studies have been carried out utilising this microarray. This includes analysis of avocado exposed to flooding in the presence and absence of the pathogen, profiling the infection progression in a tolerant and susceptible rootstock, and dissection of the role of salicylic acid and jasmonic acid in defence signalling. These studies were complemented by use of physiological data, electron microscopy, and hormone profiling respectively. Key pathways involved in the stress response of avocado have been identified. Furthermore, comparisons such as that between the response of a tolerant and a susceptible rootstock will allow us to determine the mechanisms of tolerance in avocado to aid in future breeding programmes. Recently, through collaboration with Dr. Enrique Ibarra-Laclette, we have gained access to the draft avocado genome. This allows whole-genome studies of the genes involved in defence and abiotic responses. We have also recently acquired proteome data from avocado and will correlate this to our transcriptome data in order to refine our understanding of the response of avocado to stress.

*The role of small RNAs in the avocado-*Phytophthora *interaction*

The role of miRNAs in regulation of gene expression is well known. In order to determine their role in avocado, four libraries enriched for small RNAs from rootstocks differing in tolerance to *P. cinnamomi* will be sequenced and analysed to determine novel miRNAs involved in the interaction of *P. cinnamomi* with avocado.

Physiological responses of avocado to stress

The use of photosynthetic parameters as an indicator of plant stress has facilitated the identification of a rootstock that is tolerant to *P. cinnamomi* in addition to being tolerant to flooding. However, tolerance of this rootstock breaks down when exposed to a combination of stresses. Study of this rootstock will give us a better understanding of the synergism occurring during a combination of stresses. Additional research on plant physiology will assess the formation of reactive oxygen species (ROS), biogenesis of lignin, and callose deposition in response to *P. cinnamomi* and will compare PRR susceptible rootstocks to PRR tolerant rootstocks.

Functional analysis of gene function

A system for gene silencing is currently being developed in order to determine genes important in the interaction between avocado and *P. cinnamomi*. Focus is currently on the development of a method for transient expression

within avocado. Once this is achieved, candidate host genes can be silenced as well as silencing of pathogen genes through host-induced gene silencing (HIGS). Identification and functional annotation of key regulators, such as NPR1, are also being carried out. These genes will be used to transform *Arabidopsis* mutants in order to perform complementation studies to confirm function. The establishment of a novel pathosystem for studying compatible host-*P. cinnamomi* interactions is also underway. Additionally, the use of yeast-two-hybrid systems is being utilised to investigate protein interactions between host and pathogen proteins.

Gene expression in Phytophthora cinnamomi

Phytophthora cinnamomi sequence data will be used to assemble a transcriptome and identify candidate effector genes important in the pathogenicity of *P. cinnamomi*. Several other projects have already arisen utilising this data. Studies assessing the expression of pathogenicity genes of *P. cinnamomi* during the early infection stages in avocado are currently underway and will provide insight into the infection process so that key genes can be identified and provide candidates for the HIGS system that the lab is establishing. Some of these genes include RxLR effectors, CRN effectors, and elicitors.

Transformation of Phytophthora cinnamomi

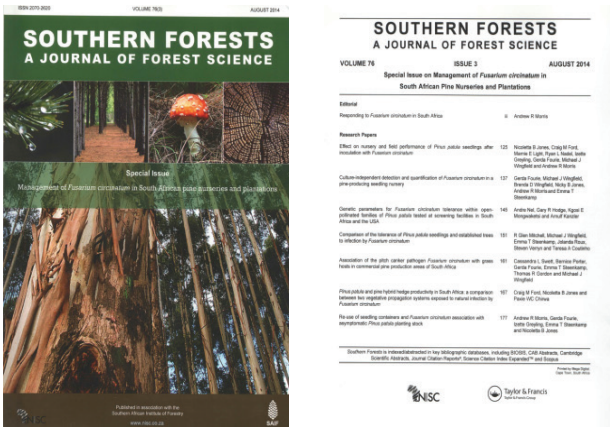
The transformation of *P. cinnamomi* will aid our ability to understand the interaction of the pathogen with avocado. Our aims are to transform the pathogen with GFP in order to perform localisation studies using confocal microscopy. Other constructs, such as those encoding RNAi cassettes which interfere with candidate genes could also be introduced for functional assessment of genes.

Mohamed Seedat, Waheed Mahomed (left), Packhouse Manager, Juanita Hannemman and Nadine Koen (right) in the avocado packhouse at the Westfalia Estate.

FUSARIUM RESEARCH AT FABI

Research leader: Prof. Emma Steenkamp

Research team: Prof. Brenda Wingfield
Prof. Mike Wingfield
Prof. Jolanda Roux
Dr. Martin Coetzee
Dr. Sanushka Naidoo
Dr. Lieschen de Vos
Dr. Albé van der Merwe



Front and back cover of the special issue on "Management of *Fusarium circinatum* in South African pine nurseries and plantations" of the journal *Southern Forests*. All of the papers present work that emanated from a large joint effort between FABI, the Forestry industry and other institutes.

OBJECTIVES OF THE RESEARCH PROGRAMME:

The *Fusarium* (previously *Gibberella*) *fujikuroi* complex (FFC) represents a monophyletic assemblage of medically, veterinary and agriculturally important species. These species are excellent subjects for studying a range of fundamental biological phenomena involving their genetics and evolution, as well as issues of a more practical or applied nature. For the latter, we focus primarily on the pine pitch canker pathogen *Fusarium circinatum*, which is also a member of this complex. In fact, most of our questions in 2013 and 2014 involved the genomics and pathology of this pathogen.

RESEARCH HIGHLIGHTS:

- Since its initial discovery in South Africa, the pitch canker pathogen has remained a significant impediment to pine production in the country. This is also true in almost all countries where pine is cultivated for commercial purposes. Although the symptoms associated with this pathogen are quite unique, we have recently discovered a range of additional fungi that are apparently capable of causing symptoms similar to those induced by *F. circinatum*. Following extensive characterisation of these fungi, we have named them *Fusarium fracticaudum*, *F. parvisorum*, *F. marasasianum*, *F. pinemorale* and *F. sororula*. Of these, three (*F. marasasianum*, *F. parvisorum* and *F. sororula*) displayed levels of pathogenicity to pine that are comparable with that of *F. circinatum*. These new and apparently emerging pathogens thus represent a significant risk to forestry both locally and in other parts of the world.

- Genomics is a major field of research that already has and that will continue to impact all fundamental and applied research, regardless of the focal organism(s). This is also true for *Fusarium* species in the FFC. During 2014, our work on the genomics of these fungi has revealed unexpectedly high levels of synteny among the genomes of species in the FFC. We have also discovered that the chromosomal complement of *F. circinatum* includes an apparently dispensable chromosome, which might be important for understanding the pathology of this fungus. A notable milestone for this period was also the anchoring of the available genetic linkage map for this fungus to its genome sequence information.

- 2014 also saw the publication of a special issue on the management of *F. circinatum* in SA pine plantations. The work captured in this journal issue demonstrated some of the outputs of the FABI-Forestry industry research projects over the last couple of years, which all focus on reducing risks associated with pitch canker in South Africa. Among the various papers included in this issue, those involving FABI students or staff dealt with the pathogen's effect on the field performance of planted pine seedlings, its inoculum sources and loads in the nursery, and the apparent ability to colonise living grass tissue.

- Collectively, our research on the pitch canker pathogen has shown that human activity represents the most important risk associated with the pathogen, although the picture will probably change with the increased influence of global and climate change. However, our research on the genomics of this and related fungi could potentially provide a suitable avenue for controlling it. Indeed, the availability of whole genome sequence information for various *Fusarium* species and several strains of the pitch canker fungus (all generated at FABI) have set the stage for a detailed exploration of the molecular processes underlying important biological traits (including pathogenicity) in this and other fungi in the FFC.

Symptoms on pine seedlings caused by *F. circinatum* isolated from grasses growing in the understory of a pine plantation, which suggests that grass might represent a potentially important aspect of the epidemiology of this fungus (top: non-inoculated control; left: seedling inoculated with an isolate from grass; right: seedling inoculated with *F. circinatum*).

MOLECULAR PLANT PATHOGEN INTERACTIONS (MPPI)

Research leader: Prof. Dave Berger

Research team: Dr. Bridget Crampton
Dr. Sanushka Naidoo
Prof. Zander Myburg

Fig. 1 Maize-GLS project team members from MPPI (FABI, UP), PANNAR and UKZN.

OBJECTIVES OF THE RESEARCH PROGRAMME:

The MPPI research group is involved in a range of research projects that address the general hypothesis that gene expression dictates phenotypes in plants, with particular emphasis on plant-pathogen interactions. The main objective of the MPPI research programme is to gain an understanding of the molecular mechanisms of both (i) plant defence and (ii) pathogen virulence. In this report we will highlight progress made in the maize-grey leaf spot project, which has collaborators from the CFPRG and FMG in FABI.

RESEARCH HIGHLIGHTS:

Grey leaf spot (GLS) disease of maize is of global concern to both commercial large-scale farmers and small-holder farmers. The incidence of GLS is on the rise due to the increased adoption of conservation tillage on maize farms. GLS is a well-known maize disease in the USA and parts of Africa, but is now also widespread in South America and China. Two distinct fungal species, *Cercospora zeae-maydis* and *Cercospora zeina*, are known to cause the characteristic matchstick-like GLS lesions on maize leaves (see Fig 2). In previous work, the MPPI lab confirmed that isolates from GLS in different African countries were *C. zeina,* and that *C. zeae-maydis* does not appear to be present.

Commercial farmers control GLS to some extent with fungicide sprays, however this solution is not readily available to small-holder farmers. In addition, society is seeking alternatives to chemical control. The development of maize varieties with host resistance to GLS is an attractive goal. Maize germplasm is known to contain sources of quantitative resistance to GLS, although most field experiments had been conducted with US-adapted material in the USA.

The MPPI group chose to work with a sub-tropical maize recombinant inbred line (RIL) population that was more suited to production conditions in Africa. The RIL population was derived from two parental lines that differed in their susceptibility to GLS (Fig 2). We collaborated with PANNAR Seed (Pty) Ltd and the University of KwaZulu-Natal to conduct field trials over three seasons at five field sites in KwaZulu-Natal, which is a hotspot for GLS (Fig 1). This illustrates the beauty of a RIL population. Each RIL represents a shuffling of genomic fragments from the parents but most fragments are genetically fixed in homozygous state. Therefore, comparative GLS disease data can be collected from the RIL population planted at multiple sites and seasons (environments).

The RIL population showed transgressive segregation (i.e. some RILs were more resistant or susceptible than the parents) indicating that resistance was quantitative. Seven QTL for GLS resistance were identified by composite interval mapping of the GLS disease scores from all the field trials (Berger *et al*. 2014). Four GLS resistance alleles were derived from the more resistant parent, and the remainder were from the more susceptible parent. Several of the QTLs were detected in multiple environments, and one QTL explained up to 22% of the phenotypic variation.

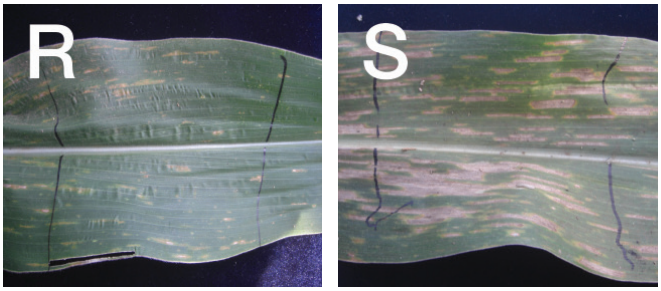


Fig. 2 Grey leaf spot disease of maize: contrasting symptoms on leaves of resistant (R) and susceptible (S) parental lines.

Comparison of the QTL to previously reported QTL for GLS resistance was made possible by allocating QTL to genomic bins on the standardised IBM 2005 maize genetic map. QTL identified from this subtropical maize population on chromosome four and seven corresponded to “hotspots” of GLS resistance QTL. Hotspots may reflect common breeding origin or clusters of resistance genes. In contrast, QTL for GLS resistance on chromosomes six and nine appeared to be unique, which may represent novel resistance genes or alleles.

The results of this study are being implemented in the maize breeding programmes of PANNAR and UKZN, through introgression of the QTL in different maize backgrounds and development of hybrids. Furthermore, the MPPI group has ongoing transcriptomics projects to understand the molecular basis of susceptibility and resistance to GLS in maize. Funding for the project was provided by the Technology Innovation Agency, PANNAR and UP. A feature of this project is that postgraduate students not only work in the lab, but are also exposed to field work in the context of the maize industry.

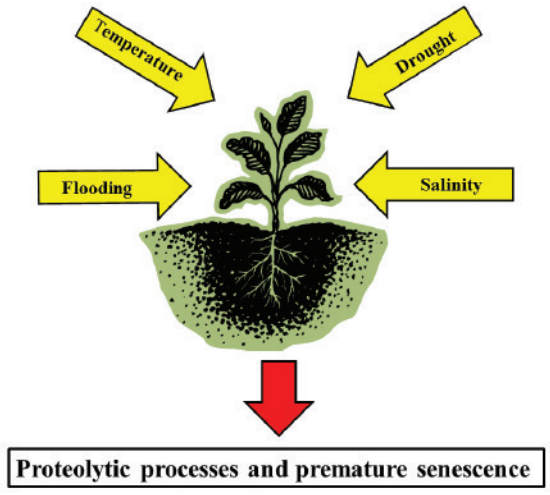
MOLECULAR PLANT PHYSIOLOGY PROGRAMME

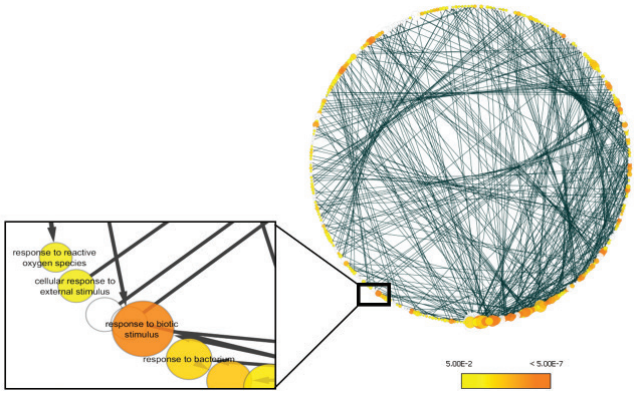
Research leaders: Prof. Karl Kunert
Dr. Juan Vorster

Research team: Prof. Christine Foyer (University of Leeds, UK)
Prof. Dominique Michaud (Universitè Laval, Canada)
Dr. Eugene Makgopa

OBJECTIVES OF THE RESEARCH PROGRAMME:

Our research objectives are to identify the role of cysteine proteases and their inhibitors (cystatins) during nodule development and senescence under optimal and drought conditions. We are specifically looking at delaying nodule senescence and improving nitrogen fixation.





A biological process network constructed from the soybean nodule transcriptome of genes showing significant levels of differential expression between the three time points (4, 8 and 14 weeks). Circular nodes represent different biological processes while the colour scale from yellow to orange represent processes significantly ($p < 0.05$) over-represented in the analysed datasets. White nodes represent biological processes that are not represented in the gene sets.

RESEARCH HIGHLIGHTS:

Soybean is the fourth most important crop worldwide. However, crop yield is severely hampered by environmental conditions, which ultimately has a detrimental effect on the food security of millions of people.

By studying gene function through transcriptome analysis combined with whole-plant physiology, the project is gaining insight into plant and nodule development, nitrogen fixation and the effect of drought on these processes. During 2013 to 2015 we generated eight whole transcriptome datasets for nodule development under optimal as well as under different levels of water-limited conditions. Analysis of these datasets has so far revealed differences in the expression patterns of a whole range of genes involved in the antioxidant networks as well as cysteine proteases and their inhibitors. Elevated cysteine protease activity is causing severe protein degradation and ultimately nodule death. We observed interesting differences in the members of the cysteine protease family of genes expressed during the onset of age related nodule senescence and those expressed during the onset of senescence in younger nodules induced by drought stress. The latter might provide good candidates for targeted inhibition to delay or prevent senescence in young nodules due to drought stress.

Based on the results above we have recombinantly expressed and isolated the soybean cystatins in *Escherichia coli* cells and used them in inhibition assays to test their strength against individual model proteases as well as against proteases extracted from nodules too identify strong inhibitor candidates.

Our collaborators in the UK successfully expressed a rice cystatin gene in soybean through genetic engineering techniques. The oryzacystatin protein was found to interact with soybean growth hormones. The result showed that plants have higher protein content, have higher photosynthetic rates and are more stress tolerant. We are therefore considering the potential use of the cystatins or cysteine protease inhibitors in general crop improvement and protection due to changing climatic conditions.

Plants had to develop mechanisms to survive in harsh environments. Our work carried out with collaborators in the UK, USA, Canada and Africa contributes to understand these mechanisms in more detail through an integrated approach of genomics, proteomics and whole plant physiology The ultimate goal is to allow plants to survive abiotic threats in environments relevant to Africa by applying the learnt principles to the improvement of crops that are better adapted to changing climatic conditions.

POTATO PATHOGEN AND PEST INTERACTIONS RESEARCH

Research leader: Dr. Lucy Moleleki

Research team: Prof. Teresa Coutinho
Prof. Jacques Theron
Dr. Sanushka Naidoo

OBJECTIVES OF THE RESEARCH PROGRAMME:

The research programme studies molecular interactions between potato plants and its pests and/or pathogens. Currently there are two main research focus areas. The first research focus is on soft rot bacterial pathogens (soft rot enterobacteriaceae [SRE]) and the second focus is on potato root knot nematodes (RKN). The objectives of our research are:

- Molecular identification of potato pathogens and pests.
- Functional characterisation of bacterial virulence factors.
- Elucidation of potato plant responses elicited by both SRE and RKN.

RESEARCH HIGHLIGHTS:

Potato root knot nematodes research focus area:

Root knot nematodes, also known as *Meloidogyne* spp. are important pests of many plants worldwide. The current withdrawal of chemical nematicides from the market has exacerbated the existing threat of RKN nematodes in crop production. In a recent review (Onkendi *et al.*, 2015) we discuss the challenges facing researchers and growers in understanding and effectively dealing with the threat of RKN in crop production. The emanating threat of RKN towards crop production, especially potato production, calls for innovative research approaches to try to manage this threat. In this respect, our research focuses on investigating alternative methods (that do not rely on the use of nematicides) of controlling RKN. Previously we had shown that there is a synergistic relationship between SRE and RKN (Mongae *et al.*, 2003). Hence, we have initiated a project where we are screening commercial potato cultivars for presence of resistance to RKN. We also investigate the use of defence ilicitors such as BABA, Harpin and others to induce resistance against not only RKN but associated SRE (Mongae *et al.*, 2015).

Potato soft rot research focus area:

Amongst the different soft rot Enterobacteriaceae, *Pectobaterium carotovorum* subsp. *brasiliensis* (*Pcb*) was identified as the most important pathogen of potatoes not only in South Africa but also in East Africa (Onkendi *et al.*, 2014); Onkendi and Moleleki, 2014). Since *Pcb* is such an important potato pathogen regionally, much of the current research focuses on virulence mechanisms that *Pcb* utilises to infect potato stems and tubers as well as studying cognate defence responses in the host plant potato.

Identification of Pcb tolerant cultivars and associated defence mechanisms

Resistance to soft rot pathogens in potatoes is generally rare. Often partial resistance, based on stems or tubers, has been identified. In this project we screened different potato cultivars against *Pcb* infection. While most commercially available cultivars tested were highly susceptible to *Pcb* and developed excessive blackleg symptoms, one of the cultivars that appeared to be highly tolerant to *Pcb* subsequently did not develop visible signs of blackleg symptoms. Using mCherry tagged *Pcb*, we observed that *Pcb*_mCherry accumulated in the xylem vessels of the susceptible cultivar. It formed biofilm-like aggregates that eventually led to complete occlusion of xylem vessels. Interestingly, *Pcb* was unable to form these biofilm like aggregates in the resistant cultivar and appeared to be dispersed in the stem (with no specific tissue preference). Henceforth, we have used RNAseq to determine the global differential transcriptome profiles of the susceptible vs. tolerant cultivars. Furthermore, ssRNA_Seq approach allowed us to determine long non-coding RNAs that are associated with *Pcb* challenge.

Collins Tanui inoculating potato plants wth *Pectobacterium* bra 1

Pcb weaponry used to colonise potato stems

To understand *Pcb* mechanisms, we used confocal and transmission electron microscopy to follow *Pcb* colonisation of a susceptible vs. a tolerant cultivar. We observed development of an intricate network of cellulose matrix and ultimate encapsulation of *Pcb* cells with an extracellular polysaccharide (EPS) that protects bacteria from the onslaught of host defences. We were interested in genes involved in formation of this EPS matrix and used a random mutagenesis approach. Screening of this library identified at least 19 genes that are important for EPS and biofilm formation. We used starvation media to study genes involved in the ability of *Pectobacterium* spp. to adapt and cope with hostile nutrient deficient conditions (starvation) typical of xylem tissue (Petrova *et al.*, 2014). In this respect, using ssRNA_Seq, we identified a number of sRNA that play an important role in adaptation and survival under nutrient limited condition (Kwenda *et al*., 2014). Quorum sensing, a density dependant form of communication in bacteria, is a global regulator of many virulence genes for most *Pectobacterium* spp. We evaluated the role of quorum sensing in the ability of *Pcb* to colonise potato stems. In this respect, we generated a mutant defective in the ability to synthesise Acyl Homoserine Lactones (AHL), a key molecule that mediates density dependent communication in bacteria (AHL). From our results, quorum did not seem to regulate the ability of *Pcb* to form aggregates in vascular tissues on stems of a susceptible potato cultivar. Thus future research will attempt to identify major regulatory pathways governing the ability of *Pcb* to form biofilms *in planta.*

PHYTOBACTERIOLOGY PROGRAMME

Research leader: Prof. Teresa Coutinho

Research team: Prof. Fanus Venter
Prof. Mike Wingfield
Prof. Lucy Moleleki
Prof. Jolanda Roux
Dr. Pieter de Maayer
Dr. Teresa Goszczynska (ARC-PPRI)
Dr. Yolanda Petersen (ARC-Infruitec)
Dr. Mariette Truter (ARC-PPRI)

OBJECTIVES OF THE RESEARCH PROGRAMME:

- Develop rapid, reliable methods of accurately identifying phytopathogenic bacteria.
- Characterise and type isolates of pathogenic bacteria responsible for economically important diseases of *Eucalyptus* and selected agricultural crops.
- Study the epidemiology, ecology and biology of selected emerging plant pathogenic bacteria.
- Identify pathogenicity factors of selected plant pathogenic bacteria using a genomic approach.

RESEARCH HIGHLIGHTS:

Bacterial diseases of Eucalyptus

Bacterial blight and die-back of *Eucalyptus* is a perplexing disease. We have shown that different bacteria are capable of causing identical symptoms in this host. These include *Pantoea ananatis*, at least three different *Xanthomonas* and two *Enterobacter* species. The only obvious difference is the severity of the symptoms. In the early 2000s there was a serious outbreak of the disease on a single clone in Zululand. Although *P. ananatis* was isolated, the primary causal agent was identified as *X. vasicola*. This bacterial species is a known pathogen of sugarcane causing gummosis. The infected plantation was surrounded by sugarcane fields and we suspected that the bacterium jumped from this host to *Eucalyptus*. We were able to show, using a comparative genomics approach, that this host jump did in fact occur.

Pantoea ananatis is ubiquitous and it has been intriguing to discover how it infects its different hosts (plants, animals and humans) and still survive and proliferate in the environment. A comparative and functional genomics approach has been used in these studies. Pathogenicity factors such as motility, quorum sensing and the Type VI secretion system have been identified as playing a role in the infection process of this bacterium.

Similarly to blight and die-back, bacterial wilt of *Eucalyptus* is a puzzling disease. Two *Ralstonia* species are capable of causing the disease: *R. solanacearum* and *R. pseudosolanacearum*. They are geographically separated but symptoms expressed by each species are similar. In solanaceous crops, *R. solanacearum* is a primary pathogen which appears not to be the case in *Eucalyptus*. Stress factors appear to play a significant role in field outbreaks of the disease, thus suggesting that this disease is caused by opportunistic pathogens.

Bacterial canker symptoms of cherry trees.

Bacterial diseases of stone fruit trees

Pathogenic bacteria cause significant damage to stone fruit as well as to the trees themselves. A number of bacterial species and pathovars are capable of causing symptoms, these include *Ps. syringae* pathovars *syringae* and *morsprunorum, Xanthomonas arboricola* (pathovars *pruni*, *corylina, persicae*), *Agrobacterium tumefaciens*, *Pseudomonas viridiflava, Xylella fastidiosa* and *Erwinia amylovora*. Since the research conducted by Hattingh and co-workers in the 1980s, very little has been published on the bacteria and the diseases they cause on stone fruit trees in South Africa. This is unlike the situation in the rest of the world where there has been concerted efforts to understand their biology, and implement phytosanitary and tree management strategies. A research project was thus initiated in 2014 in an attempt to determine which bacterial pathogens are present and whether or not they cause economic losses to the fruit industry in South Africa.

From surveys undertaken in the 2014/15 season, we were able to establish that bacterial canker and, to some extent, bacterial spot, are the most important bacterial diseases of apricot and cherry trees in South Africa. The causal agents were identified as *Ps. syringae* pv. *syringae* and *X. arboricola* pv. *pruni*, respectively. The next step is to understand their diversity and the factors that influence disease outbreaks. Stress factors, particularly water stress, have been implicated in outbreaks of bacterial canker.

Bacterial diseases of agricultural crops

Bacterial diseases are considered by the agricultural industry to be of less importance than diseases caused by other agents. However, when they do occur the losses incurred are devastating. One of the primary sources of inoculum in initial disease outbreaks in vegetable crops is from planting contaminated seed. Our research is focusing on optimising and developing detection methods of bacterial pathogens in onion and carrot seed in an effort to reduce the introduction of pathogens into farming areas.

PLANT VIROLOGY RESEARCH PROGRAMME

Research leader: Prof. Gerhard Pietersen

OBJECTIVES OF THE RESEARCH PROGRAMME:

The research program of the Plant Virology Group focuses on grapevine leafroll disease of wine grapes and the citrus disease caused by citrus tristeza virus (CTV). The group also studies citrus greening disease, associated with a fastidious bacterium "*Candidatus*" Liberibacter africanus (Laf), which has an epidemiology not unlike that of plant viruses. These three diseases are amongst the most important diseases of wine grapes and citrus, two high value crops in South Africa.

RESEARCH HIGHLIGHTS:

Monitoring of the control strategy for grapevine leafroll disease based on planting certified planting material, rouging of infected vines and the control of mealybug numbers and dispersal has continued. During 2014 only 47 infected vines amongst 209,616 vines (0.02%) of red cultivars were detected. Eradication of the disease from Vergelegen Wine Estate in Somerset West is imminent.

A high throughput detection method based on polyvalent PCRs and next generation sequencing for the SA Wine Certification Scheme was developed and the proof of concept successfully implemented. This method is capable of detecting 41 viruses of grapevines. The system is continually being expanded to detect new genera of plant viruses. Fundamental studies on the presence of grapevine leafroll associated virus 3 in rootstocks were initiated and confirmed the low levels of the virus found in rootstocks.

A method, based on next generation sequencing, to determine the genotype composition of citrus tristeza virus (CTV) populations was developed and used to survey grapevines in South Africa. From this, clear guidelines as to the genotypes required for cross protection have emerged. Various other CTV populations, including a number of candidate-cross protecting sources were characterised. Novel methods of CTV isolation were also assessed.

"*Candidatus*" Liberibacter africanus (Laf), the cause of citrus greening in South Africa, was not found in indigenous members of the Rutaceae (citrus-family) during extensive surveys for this pathogen, but three Laf subspecies were described and shown to be specific to either *Xanthoxylum* spp., *Vepris* spp., or *Clausena* spp. within the Rutaceae.

Single leafroll infected vine, marked for removal in winter, in an entire vineyard of Cabernet sauvignon on Vergelegen Wine Estate, Autumn 2013.

SEED SCIENCE AND PATHOLOGY OF FLOWERS, TREES AND AGRONOMIC CROPS

Research leader: Prof. Terry Aveling

Research team: Dr. Quenton Kritzinger
Prof. Jolanda Roux
Dr. Mariette Truter, ARC-PPRI
Dr. Riana Jacobs, ARC-PPRI

OBJECTIVES OF THE RESEARCH PROGRAMME:

To research and solve seed problems for emerging and commercial farmers on a range of plants including seed pathology, seed vigour and seed treatments.

RESEARCH HIGHLIGHTS:

Seedborne Alternaria spp. *of sunflower*

Sunflower (*Helianthus annuus* L.) is an important oilseed crop in South Africa and is grown in summer rainfall areas. A field trip was taken to sunflower fields in Greytown, northern KwaZulu-Natal, in early March 2010 during the warm and rainy summer season. An *Alternaria* species was consistently isolated from lesions of a leaf blight disease of sunflower. The symptoms were characterised by circular, brown lesions that were surrounded by a chlorotic halo. As time elapsed the lesions coalesced to form larger lesions. The aim of this study was to determine the distribution of Alternaria leaf spot and assess the disease severity of Alternaria leaf blight on sunflower in South African production areas. Surveys were conducted in 2013 and 2014, in the North West, Limpopo, Free State, Mpumalanga and Gauteng provinces on approximately 24 sunflower production sites. The plants were surveyed after 90 to 120 days from planting. Plant parts that were showing leaf blight symptoms were collected. *Alternaria helianthicola, A. alternata* and *A. tenuissima* were found to be the disease causing agents of Alternaria leaf blight in the field based on morphological and molecular techniques. In 2013, Alternaria leaf blight disease severity from the respective localities ranged from 44 – 81%. However, there was a slight decrease in disease severity which ranged from 24 – 72% in 2014. This survey demonstrated that *Alternaria* species have been found to be widespread across the sunflower growing areas and may pose a potential threat to yields. Field trials are currently underway to determine the effect of *Alternaria* species on yield loss. Furthermore, a fungicide spray programme and seed treatments (using bio–control agents and fungicides) will be done to evaluate their efficacy in reducing Alternaria leaf blight. Other plant diseases that were identified were white rust and Sclerotina head and stalk rot.

Hot water treatment of Brassica seed infected with Xanthomonas campestris *pv.* campestris

Brassica seeds were submerged at different periods of time and temperature and a water bath was used. Seed germination tests were done according to ISTA rules. Detection of the *Xanthomonas campestris* pv. *campestris* after seed treatment was done using the ISTA method on detection of *X. campestris* pv. *campestris* on Brassica. The hot water treatments at 50°C for 20 min, 50°C for 25 min, 50°C for 30 min and 53°C for 10 min increased the percentage of germinated seeds significantly compared to the untreated infected seeds. These treatments, among others, also significantly reduced the bacterial population with 50°C for 30 min being most effective.

Plant extract treatment of Brassica seed infected with Xanthomonas campestris *pv.* campestris

Plant water extracts were dissolved directly in sterile distilled water and acetone crude extracts were dissolved in 1% DMSO (in sterile distilled water). Both extract types were dissolved to yield final concentrations of 10, 15 and 20mg/ml. Plant extracts of *Agapanthus caulescens* (acetone), *Tagetes minuta* (acetone), *Cymbopogon citratus* (acetone) and *C. citratus* (water) were selected from *in vitro* tests as seed treatments against the seed-borne *Xanthomonas campestris* pv. *campestris*. Seed germination tests were done according to ISTA rules. Detection of the bacteria after seed treatment was done using the ISTA method for detection of *X. campestris* pv. *campestris* on Brassica.

Among the plant extracts tested *A. caulescens* (15mg/ml) and *C. citratus* (10mg/ml and 15mg/ml) were the most active in reducing the bacterial counts significantly compared to untreated infected seeds. The same extracts also increased the germination percentage compared to the untreated infected control. As the concentrations of plant extracts increased (20mg/ml) seeds were damaged especially by *C. citratus* acetone extracts, there was a significant reduction in percent germination seedlings even though the bacterial population was reduced significantly.

Seed treatments of coriander

A validation study on the Coriander/*Alternaria* sp. pathosystem has been completed. Seed health tests showed that commercially available *Bacillus subtilis* and *Trichoderma harzianum* and *Zingiber* acetone extract effectively lowered the incidence of *A. tenuissima* and compared well with a Celest® XL seed treatment. Results from our study showed that seed treatments significantly improved percentage seedling emergence, except for seeds treated with *Lantana* and hot water at 48°C for 60 min, when compared to untreated seeds. Three seed treatments namely, *Zingiber* acetone extract, *Bacillus subtilis* and hot

water 54°C for 15min had seedling emergence percentages above 70%, high fress and dry masses and long shoot length and were better or comparable to the Celest® XL treatment. The lowest, or no, incidence and severity of *Alternaria* leaf spot disease on seedlings from treated seeds was found with *Bacillus* sp. and extracts of *Allium* and *Zingiber,* which compared well with seeds treated with Celest® XL.

Diseased mesemb plant.

Fungi associated with mesembs of the Namaqua National Park

Isolations of the culturable fraction of fungi from seed, plant and soil material were performed during the dry season in Namaqua National Park located in the succulent Karoo biome, one of only 35 biodiversity hotspots recognised globally. Fungi were cultured on media ranging from nutrient rich to nutrient poor, using different temperature regimes, to enable isolation of both fast and slow growing species. Fungal genera were identified morphologically and about 300 isolates were identified based on DNA sequence comparisons against known species. *Fusarium* was found to be the most commonly isolated genus during the dry season, 21% of total isolates. This was followed by *Trichoderma* (mostly isolated from soil, 10%), *Alternaria, Aspergillus, Cladosporium* and *Penicillium* (8% each) and some other genera in lesser amounts, including: *Bipolaris, Chaetomium, Curvularia, Davidiella, Emericella, Mortierella, Neocosmospora, Neosartorya, Paecilomyces, Phoma, Talaromyces*. All fungal isolates have been deposited into the National Collection of Fungi at the Agricultural Research Council. Current studies are underway to determine the unculturable fungal fraction present in seed, plant and soil samples.

Prof. Terry Aveling and Zelda Pietersen collecting diseased mesemb plants in the Namaqua National Park.

TREE PROTECTION CO-OPERATIVE PROGRAMME (TPCP)

Research leader: Prof. Mike Wingfield

Research team: Prof. Jolanda Roux
Prof. Bernard Slippers
Prof. Fanus Venter
Prof. Emma Steenkamp
Prof. Brenda Wingfield
Prof. Teresa Coutinho
Dr. Martin Coetzee
Dr. Brett Hurley
Dr. Jeff Garnas
Dr. Irene Barnes
Dr. Wilhelm de Beer
Dr. Albé van der Merwe
Dr. Kershney Naidoo
Dr. ShuaiFei Chen

OBJECTIVES OF THE RESEARCH PROGRAMME:

- Development of field monitoring techniques to recognise the appearance of new pests and diseases as well as to monitor the spread and impact of those already established in South Africa.
- Identify new and important tree pests and pathogens and evaluate their genetic structure so that they can be more effectively controlled.
- Develop methods to screen trees for tolerance to the most important diseases present in the country.
- Establish and evaluate contemporary breeding strategies in order to produce disease and pest tolerant species, clones and hybrids.
- Establish an understanding of the biology of tree pests and pathogens to promote their better management.
- Study and evaluate novel strategies for disease and pest control, particularly biological control.

Symptoms of *Uromycladium* sp. on *Acacia mearnsii.*

RESEARCH HIGHLIGHTS:

This report covers activities of the TPCP during 2013/14 but it also seeks to capture the "bigger picture" regarding issues pertaining to the health of plantation forest trees in South Africa. At the annual stakeholder meeting of the TPCP in May 2014, the programme celebrated its 25th year of existence and it was possible to take the opportunity to look back on its accomplishments during its first quarter century. At the start of the programme, clonal forestry with *Eucalyptus* had just begun in South Africa and some clones were displaying evident disease problems. Insect pests were a problem, but at that time diseases appeared to be more serious. This situation has swung in various directions over the years depending on the appearance of pests and diseases. Here the "clarion bell" is clearly that a broad view, including building capacity across a wide spectrum of approaches and existing talents and experience, will always be needed. It is also clear that there are times where focus and emphasis on a particular domain is required. It is this approach that has underpinned the growth and development of the TPCP during the last 26 years.

The forest health landscape has changed markedly during the course of the last three decades. This has not only been due to new and damaging pests and pathogens appearing, but also due to the changing face of forestry. For example, 30 years ago, clonal eucalypt forestry was only being tried on an experimental scale. Where they can be grown, serious consideration of genetic background is required in order to understand and manage affects by pests or pathogens. This is rather similar to the situation in the past where the primary species propagated in South Africa were *E. globulus* and *P. radiata.* Both species were severely damaged by diseases (Dothistroma needle blight and Mycosphaerella leaf blight) which resulted in these valuable species being virtually eliminated from the plantation environment. In this regard, it is fair to argue that pests and pathogens have had a very significant impact on the trees that are propagated in

plantations in South Africa. This is likely to be the scenario into the foreseeable future.

Managing disease and pest problems in plantation forestry is a long term proposition. This is often difficult for foresters to understand, especially when trees are dying and rapid solutions are urgently required. Today we have enough examples to clearly show how investments in disease and pest control (which in many cases have been very costly in the short term) have had substantial return on investment. A good example is found in the biological control of the black pine aphid, *Cinara cronartii*, that was hugely damaging in the 1970s, but is virtually unknown today as a consequence of a highly effective biocontrol programme. Likewise, the Eucalyptus snout beetle was well controlled via classical biological control for many years, although it is now emerging as a new and serious problem and has again become the focus of dedicated research. On the disease side, serious diseases such as Cryphonectria (*Chrysoporthe*) canker have been reduced to relatively unimportant through long term screening of clonal trials. The important message here is that South African forestry requires long-term investment in tree pathology and entomology if it is going to be sustainable into the future.

A question commonly asked of TPCP research team leaders is where a reasonable balance might lie between short-term problem solving research and research that is clearly aimed at the deeper understanding of tree disease and pest problems? This question also cuts to the heart of managing a sound relationship between a research team based at a University, but simultaneously serving a vibrant industrial sector. The TPCP track record of 26 years of maintaining a sound relationship between University and industry provides a clear example of the fact that such relationships can flourish. What is needed is a balance between the needs of a University that are focused on education and new knowledge generation and the needs of industry that often demand short-term answers. The TPCP manages this balance very carefully in order to benefit from the leverage from all sectors. Thus, students and staff members spend a considerable portion of their time in plantations engaging with industry partners, providing advice via field days and extension services linked to

Uredinia of the myrtle rust pathogen, *Puccinia psidii*, on native South African *Eugenia natalitia.*

Gonipterus adult (*Eucalyptus* snout beetle).

specific problem solving. This is counter-balanced by directed research that provides short, medium and long-term solutions to problems. It is thus not surprising that many technologies used routinely today in, for example, disease or pest diagnosis by the TPCP (and some industry partners) are those that were viewed as long-term and perhaps not urgent many years ago. One finds this for example in studies focused on recognising species boundaries that have been crucially important for TPCP work on pitch canker. Likewise, understanding the South African fungal biodiversity has allowed us to leverage funding and to understand the importance of fungi in native South African environments with the capacity to become serious tree pathogens.

Research projects of the TPCP cover a very wide range of pests and pathogens. Those most important to the forestry industry are treated briefly in this report with some focus on the work being done. What is particularly important is for the team to maintain a critical mass of activity on key pests and pathogens such that sufficient attention is given to the most important issues. Likewise, being in a University environment implies that students are present for a relatively limited time. It is thus crucially important for TPCP leaders to ensure that there is overlap in projects and that new technologies learned or developed are passed on from one student to another. This management of continuity is crucially important and it is also one of the most difficult elements for the TPCP leadership to manage.

Over the past two years there have been new records of pests and pathogens in South African forestry plantations. While wattle rust has been known to us for some years, the early part of January marked the completion of a study to identify a new Eucalyptus rust in South Africa. This rust that has the potential to be important in the future has been given the name *Phakopsora myrtacearum*. Also on the rust front, a new rust disease has emerged as being very serious in plantations of *Acacia mearnsii*. This rust remains to be identified to the species level, but is most certainly a species of *Uromycladium*. Intensive research in collaboration with the ICFR has been initiated to deal with this serious problem. On the insect front there have also been records of two new pests. The Eucalyptus leaf gall wasp *Ophelimus maskelli* has been reported recently and this insect has caused serious damage to trees in other parts of the world. The second insect is the lerp psyllid *Spondyliaspis plicatuloides* which is of unknown potential importance, but where it occurs (on trees

Colasposoma adults (bronze beetles) on *Eucalyptus* sp.

outside of the plantation environment to date), damage can be significant. Clearly, South Africa is seriously threatened by new pests and pathogens including those that have undergone host shifts and those introduced into the country accidentally. Thus, new research initiatives will need to be established to at least gain an understanding of these new problems and to treat them appropriately such that serious losses are not incurred.

While most pest and pathogen problems can be diagnosed using the available research tools, new problems arise that are much more complicated to understand. A recent example of such a problem can be found in the dramatic die-off of *Eucalyptus* clone GU178 on the Zululand coast. This problem emerged approximately five years ago on a small scale and has advanced to a point where virtually all trees of this clone have died or are dying. The TPCP has expended substantial effort in trying to gain an understanding of the cause of the problem. It is crucially important that the cause of this problem be identified, given the possibility that other clones could suffer a similar fate and losses could be unsustainable.

One of the keys to the success of the TPCP lies in the fact that it is characterised by a very substantial base of collaboration with scientists globally. This is evident in the author lines of publications linked to the TPCP and it is also consistent with the knowledge that leading research is increasingly promoted by substantial global collaboration. The team thus draws students from many different parts of the world and it also benefits from a multiplicity of international funding opportunities. Importantly for the field of tree health, pests and pathogens are moving rapidly between countries and this makes it crucially important to have knowledge of the threats, as well as the different approaches that have been taken to deal with them. These associations have led to important initiatives such as BiCEP (Biological Control of *Eucalyptus* Pests) that is already playing a major role in promoting biological control of *Eucalyptus* pests in South Africa.

Euproctis terminalis larva
(Cape brown tail moth) on a *Pinus* sp.

Biological control of plantation insect pests has become a key component of the TPCP research focus. While this began and still continues to be strongly linked to the biological control of the Sirex wood wasp, a growing focus has been on the many new *Eucalyptus* pests that have become established in South Africa in recent years. Thus a highlight of the TPCP biological control programme was the release in 2012 of the first biological control agent for the gall wasp, *Leptocybe invasa*. This parasitoid, *Selitrichoides neseri* has been monitored closely post its release and it is now known to have spread widely in South Africa. Anecdotal evidence suggests that it is already impacting strongly on the populations of the pest and quantitative data are gradually becoming available. During 2013 we received official permission to release a biological control agent for the bronze bug, *Thaumastocoris peregrinus*. This egg parasitoid, *Cleruchoides noackae* has been sourced from Australia and has now been released at a multiplicity of sites. Research and initiatives are now underway to enhance the biological control of the above-mentioned insects and also to launch a substantial programme for the biological control of the *Eucalyptus* snout beetles of the genus *Gonipterus*. Funding in 2014 from Sappi and from the Sector Innovation Fund (SIF) of the Department of Science and Technology will make it possible to expand TPCP facilities to enhance current biological control efforts.

The 26th year of activity of the TPCP was characterised by many achievements and successes on the part of the research team. As in the past, this could not have been possible without the support of member forestry companies, various organisations providing leverage support for the programme and the many forest managers and foresters with whom the team members engage actively and regularly. Overall, the success of the TPCP is attributable to an incredible passion and team effort on the part of a remarkable group of people. It is this team effort that makes it possible for us to achieve our overarching goal, which is "KEEPING TREES HEALTHY".

SABBATICAL VISITS

Prof. Jolanda Roux

Host: Prof. Andre Drenth and Dr. Geoff Pegg

Location: Centre for Plant Sciences, University of Brisbane and Queensland Department of Agriculture, Forestry and Fisheries in Brisbane

Duration: February to April 2013

Objectives: Study tree pathogens in the families *Cryphonectriaceae* and *Ceratocystidaceae* on native Australian Myrtaceae, develop experience in working with the Myrtle rust pathogen, *Puccinia psidii.*

Jolanda discussing the biology of *Ceratocystis* species with a student during a field visit.

Dr. Geoff Pegg and Jolanda in Northern Queensland during a field visit.

Prof. Andre Drenth is a principal research fellow in the Centre for Plant Science (Queensland Alliance for Agriculture & Food Innovation (QAAFI)) at the University of Brisbane. He has considerable expertise in working with and managing diseases caused by *Phytophthora* species in horticulture and forestry. He has visited South Africa a number of times as consultant to the macadamia and other fruit industries and has also presented a population biology workshop at FABI in the late 1990s. Dr. Geoff Pegg is a forest pathologist working at Queensland Department of Agriculture, Forestry and Fisheries. He has been leading research into understanding and managing eucalypt diseases in Queensland, including Quambalaria leaf and shoot blight and most recently, the myrtle rust pathogen, *Puccinia psidii.*

Prof. Jolanda Roux secured funding from the Oppenheimer Trust in South Africa to facilitate a short sabbatical visit to Australia to visit Andre and Geoff to establish collaborative research and gain experience in working with *P. psidii*. At the time, in early 2013, *P. psidii* had not yet been reported from South Africa, but it was predicted that it was only a matter of time before it arrived in the country. A second aim of her sabbatical visit was to survey for fungi in Cryphonectriaceae and Ceratocystidaceae. These two families include important pathogens of plantation forestry species in South Africa and elsewhere and have been the focus of research in the TPCP and CTHB research programmes for several years. The origin of some of these pathogens is suspected to be Australia. During her sabbatical Jolanda, Geoff and Andre, conducted surveys on native Australian Myrtaceae plants to identify fungi in these two families that may occur asymptomatically on native hosts in Australia.

The myrtle rust pathogen, *P. psidii*, was detected in Australia for the first time in 2010. Because of the concern regarding the impact of this pathogen on Australia's native biodiversity, which includes more than 90 genera in the Myrtaceae, scientists in the country have developed significant expertise and experience in working with this pathogen. During her time in Brisbane, Jolanda and Geoff, together with Dr David Lee, a tree breeder, selected several eucalypt families, of interest to the South African forestry industry, to screen for resistance to *P. psidii*. Seeds were sourced and germinated, whereafter seedlings were inoculated with a spore suspension of *P. psidii.* Results from this screening experiment, together with climatic risk mapping done in collaboration with Dr Ilaria Germishuizen of the Institute for Commercial Forestry Research (ICFR) in South Africa were combined and have since been published. The work conducted by Jolanda,

Dr. Geoff Pegg inoculating *Eucalyptus* families of interest to South Africa with the myrtle rust pathogen, *Puccinia psidii.*

Geoff, David and Ilaria showed that commonly planted eucalypt genotypes in South Africa are at risk of infection by *P. psidii.* Additionally, several areas where commercial plantations occur in South Africa are in high-risk climatic regions for the establishment of the pathogen. Several field visits were also made with Geoff to rust affected sites in Queensland and Jolanda assisted with the evaluation of rust trials during this time.

Developing *P. psidii* infection points on a *Eucalyptus* species.

Field visits were undertaken to northern Queensland, around Brisbane and several other locations in the region to survey for species of *Ceratocystis* and fungi in the *Cryphonectriaceae*. A focus was placed on native Australian Myrtaceae, so as to gain information on possible future threats to the eucalypt industry in South Africa, and globally. The *Cryphonectriaceae* includes important tree pathogens such as *Chrysoporthe* species that cause stem and root collar cankers on eucalypts and *Cryphonectria parasitica*, the cause of chestnut blight in Europe and the USA. *Ceratocystis* species are known for an important disease of eucalypts in South America and the Republic of the Congo, a devastating disease of *Acacia mangium* in Malaysia and a wilt disease of *Acacia mearnsii* in South Africa. Several novel species of *Ceratocystis* and *Cryphonectriaceae* have been discovered over the past two decades, but limited information is available about these fungi in Australia. During Jolanda's sabbatical she and Geoff collected several isolates of these fungi which will be identified.

Jolanda also met with entomologists of DAFF, namely Dr. Simon Lawson (BiCEP) and Dr. Helen Nahrung. Simon and Helen have been collaborating with the TPCP for the past few years on insect pests of eucalypt and *Pinus* species. Part of the collaboration has involved the sending of biological control agents for the bronze bug (*Thaumastocoris peregrinus*) and gall wasp (*Leptocybe invasa*) to South Africa. Towards the end of her sabbatical Jolanda presented a talk on tree health and some of the TPCP and CTHB's research to the University of Queensland and had the opportunity to learn more about fruit tree diseases during a field visit with Prof. Drenth.

Prof. Andre Drenth, showing Jolanda some *Phytophthora* disease symptoms on fruit trees.

It was not all work. Andre and Geoff and members of their research teams made sure that Jolanda experienced some good Aussie hospitality. Andre also made sure she kept fit, with regular mountain biking excursions on Mount Cootha. Jolanda is grateful for the opportunity to spend time with Andre and Geoff and for all their time and hospitality. The Oppenheimer Foundation is also acknowledged for providing the funding to make this valuable sabbatical visit possible.

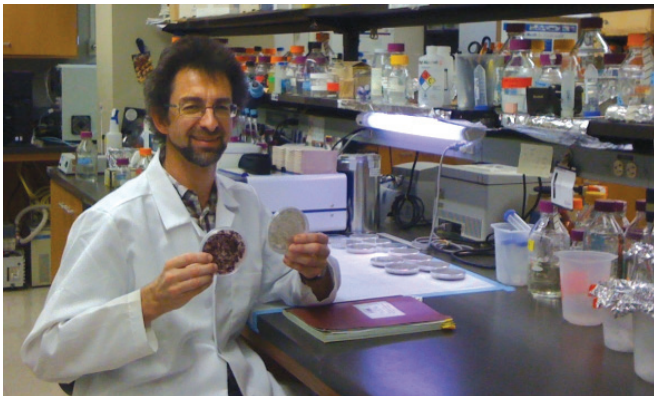
Prof. Dave Berger

Host: Prof. Burt Bluhm

Location: Department of Plant Pathology, University of Arkansas, Fayetteville, USA

Duration: August to November 2013

Objectives: The objective of the visit was to collaborate with Prof. Bluhm in developing functional genomics (i.e. gene knockout) tools for the fungus *Cercospora zeina* that causes the economically important grey leaf spot disease (GLS) of maize in Africa.



Dave in the Bluhm lab at the University of Arkansas.

Prof. Bluhm is a fungal geneticist whose research programme in the Department of Plant Pathology at the University of Arkansas is linked to important diseases of maize. Much of his research focuses on the pathogenicity mechanisms of *Cercospora zeae-maydis* and *Fusarium verticillioides*, the causal agents of GLS disease and Fusarium ear-rot, respectively. His collaboration with FABI stems from his visit as a keynote speaker at the 47th Congress of the Southern African Society for Plant Pathology. Prof. Bluhm subsequently invited Dr. Bridget Crampton, leader of the Cereal Foliar Pathogens Research Group (CFPRG) in FABI, for a short research visit to Arkansas to gain experience in fungal gene knockouts using *Fusarium*, which is relatively routine in his laboratory. Mischa Muller from the MPPI group visited the Bluhm Lab at the same time, where she initiated her MSc study on the diversity of *C. zeina* in South Africa by designing her first batch of SSR markers.

Prof. Dave Berger was able to secure a US Department of Agriculture (USDA) Norman E. Borlaug International Agricultural Science and Technology Fellowship to facilitate his sabbatical visit to the Bluhm Lab at the University of Arkansas. These fellowships were established in honour of Norman Borlaug, recipient of the Nobel Peace Prize in 1972, for his role in breeding improved varieties of wheat, which led to the Green Revolution. The fellowships provide opportunities for agricultural researchers around the world to work with US scientists for periods of up to three months.

Prof. Bluhm's lab has set up various tools for the study of *C. zeae-maydis* at the molecular level, namely protoplast transformation, confocal microscopy, cercosporin assays, and growth chamber inoculations. *Cercospora zeae-maydis* is the predominant pathogen causing GLS in the USA, however *C.zeina* is also found in the eastern states of the USA, which facilitated the sabbatical research in the Bluhm Lab.

Dave spent a considerable part of his sabbatical working in the lab. This was somewhat of a luxury to work like a postdoc again, in contrast to being tied to the computer screen as principle investigator of the MPPI group in FABI. The research questions that Dave attempted to answer were mainly linked to the role of the toxin cercosporin in the pathogenicity of *C. zeina*. Cercosporin is the archetypal toxin of the fungal genus *Cercospora*. *C. zeae-maydis* produces it in abundance when grown *in vitro* under nitrogen-limiting conditions, and it is thought to be an important contributor to cell death that results in the typical lesions on maize leaves. Identical symptoms are caused by *C. zeina*, however there is a conundrum that *C. zeina* does not produce the toxin *in vitro*.

Dave conducted maize inoculation experiments with *Cercospora* spp. He was able to observe under the microscope erumpent conidiophores emerging from stomata, thus confirming completion of the fungal infection process *in vivo*. He also investigated the phytotoxicity of cercosporin, and assisted with some of the ongoing *C. zeae-maydis* experiments in the Bluhm Lab.

Prior to the sabbatical, a PhD student in the MPPI Lab, Velushka Birkenbach had observed a difference in the gene structure of one of the toxin biosynthesis genes between the two fungal species. Dave was able to screen a collection of isolates in the Bluhm Lab to determine whether this difference was universal. The Bluhm Lab has optimised gene-knockouts in fungi using the split-marker approach, and has published a book chapter outlining a step-by-step protocol for *Fusarium*. Following this approach, Dave built a construct for knockout of one of the key cercosporin biosynthesis genes in *C. zeina* using the split-marker approach. The construct and primer design for the knockout is being applied in a current MSc project at the MPPI Lab.

Continuity from the sabbatical visit was ensured by the visit in 2014 of Kara Troglin from the Bluhm Lab to FABI. Kara has had extensive experience with *C. zeae-maydis*. She spent several weeks working on *Cercospora*-related projects with postgraduates in the CFPRG and MPPI groups. During her visit, Dave arranged a fungal transformation workshop in FABI where staff and students interested in transformation of other fungi went through the process of making protoplasts, transformation and regeneration. The workship was a success as GFP positive colonies were obtained!

The Borlaug Fellowship also allowed Dave to make a brief visit during his sabbatical to the Yale Center for Genome

Analysis (YCGA), Connecticut. YCGA is a genomics service facility that serves mainly the biomedical community in the eastern states of USA, however it has a PacBio genome sequencer. PacBio is a single-molecule sequencer that produces longer reads than the standard Illumina technology. Including a PacBio run together with Illumina data in a fungal genome sequencing project has the advantage of improving the assembly by joining contigs into larger scaffolds. Dave was interested in implementing this approach for the *C. zeina* genome sequence.

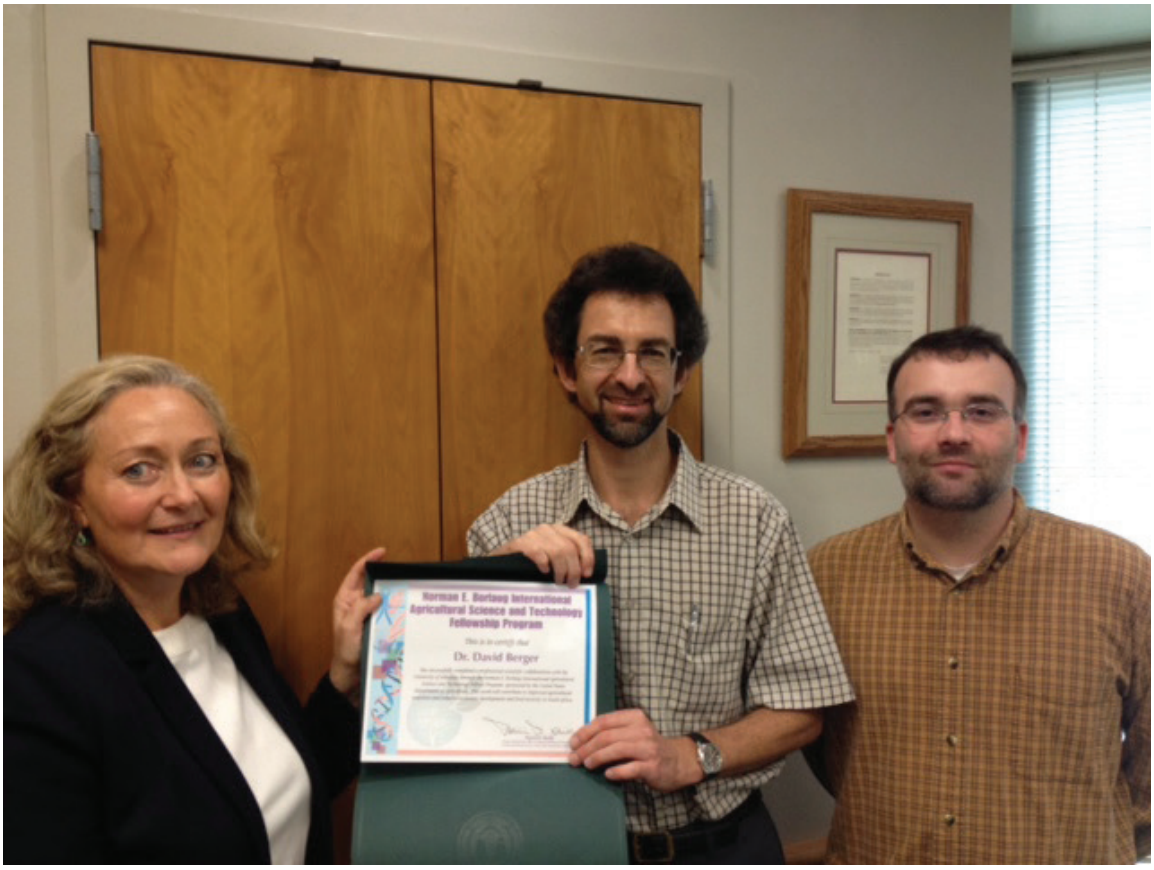
Dave also got involved in some trans-Atlantic teaching activities during the sabbatical visit, collaborating with Prof. Ken Korth at the University of Arkansas. They developed a questionnaire about GM crops and food security. This was completed simultaneously by the Agricultural Biotechnology class at the University of Arkansas, and the Plant Genetics and Crop Biotechnology third year and Honours classes at the University of Pretoria. Survey results were shared between classes and formed the basis for discussions about the perceptions of students from different countries. The survey is now implemented in the curriculum at both Universities on an annual basis.

Prof. Bluhm was an engaging host during the sabbatical visit, not only ensuring that Dave was able to work with most members of the Bluhm Lab, but also arranging several American cultural experiences. Two epic road trips with scientific destinations were carried out. The first was a 1,100 km drive in a single day from Fayetteville in Arkansas to Purdue University in the State of Illinois. There Dave was able to visit the Purdue Genomics Facility to discuss progress on the *C. zeina* genome sequencing, and visit with several members of the Department of Plant Pathology and USDA labs at Purdue.

The second road trip (700km in a day) was to Des Moines, Iowa, to attend the World Food Prize, thanks to the USDA Fellowship. This is an annual gala event initiated by Norman Borlaug, and considered to be the "Nobel Prize for Agriculture". Dave got to attend the awards ceremony in the State Capitol, where the 2013 Awardees were Marc von Montagu, Robert Fraley and Mary-Dell Chilton. They were recognised for their research on Agrobacterium-mediated T-DNA transfer that led to the technology of genetically modified plants. Interestingly, the award was based on their separate papers on DNA transfer from Agrobacterium to plants presented at the same meeting in Florida in 1983. Many luminaries in food security presented during the World Food Prize conference, and Dave even got to meet Marc von Montagu. A highlight was the award of the Norman Borlaug Prize for Field Research to Charity Mutege from Kenya for her work in implementing biological control to reduce Aflatoxin contamination of maize.

Serendipity led to a chance meeting at the World Food Prize with Prof. Willi Meyers, Director of International Agricultural Programmes at University of Missouri, who was conducting a project with small-holder farmers in South Africa. This gave impetus to Dave's project on the impact and diversity of foliar diseases in small-holder maize farms, which was subsequently funded by the DAFF Research and Technology Fund. PANNAR is a partner on this project, which expands the impact of the research in the MPPI group from diseases of commercial maize farmers to small-holders as well.

Dave is grateful to the USDA for funding from the Borlaug Fellowship programme, and to the Department of Plant Pathology at the University of Arkansas, especially Prof. Burt Bluhm and members of the Bluhm Lab for the rewarding sabbatical experience and the prospect of continued collaborations with FABI.



Dave receiving his USDA Fellowship certificate from Karen Utrecht (Africa Programme Manager, Scientific Exchange Programmes, USDA) with Dr. Burt Bluhm, University of Arkansas.

Prof. Teresa Coutinho

Host: Prof. Altus Viljoen, Dr. Cheryl Lennox and Dr. Yolanda Petersen

Location: Jointly hosted by the Department of Plant Pathology, Stellenbosch University, and ARC-Infruitec, Stellenbosch, South Africa

Duration: 1 September 2014 to 31 May 2015

Objectives:

- Conduct surveys in stone fruit tree orchards in the Western Cape to assess the role played by phytopathogenic bacteria in reducing fruit and tree losses.
- Isolate and identify these bacteria.
- Write a review paper on opportunism in plant pathogenic bacteria.

Since the 1980s very little research has been conducted on bacterial diseases of stone fruit trees in South Africa. The fruit industry acknowledged that they are present, but the causal agents, incidence and severity are unknown. Surveys were thus conducted in all the major fruit growing areas of the Western Cape including Ceres, Koue Bokkeveld, Franschoek, Robertson, Montagu, Bonnievale, Riviersonderend and the Stellenbosch area. Although surveys were undertaken in all the different stone fruit tree orchards, it was evident that bacterial canker and to a lesser extent bacterial spot was problematic in apricot and cherry orchards, and occasionally on plum trees. The causal agents were identified as *Pseudomonas syringae* pv. *syringae* and *Xanthomonas arboricola* pv. *pruni*. These surveys were the first and most important step in a newly funded project in FABI. The strains isolated and identified will be included in a study by a PhD student, Margot Muller. The discovery of bacterial cultures from the 1980s in the ARC-Infruitec collection was an added bonus and they will now be included in the study to determine if there was a change in the population structure of these two pathogens over time.

Ihan du Plessis, Margot Muller, Teresa Coutinho and Yolanda Petersen in a cherry orchard.

Ihan du Plessis, Teresa Coutinho and Yolanda Petersen collecting samples from cherry trees.

Bacteria are inextricably associated with plants and animals. This relationship ranges from symbiotic, commensal to pathogenic. Through the process of horizontal gene transfer some bacteria acquired pathogenicity islands harbouring virulence factors which then allowed them to infect their hosts. These bacteria are regarded as true pathogens. In opportunistic bacteria, the evolution towards virulence is rather different as these organisms do not infect healthy hosts and the main factor allowing infection is the host's predisposition to being infected. Thus opportunistic human pathogens are considered to be those that do not usually infect healthy hosts but become pathogenic following a change in the host which includes disease, wounds, medication, prior infection, immunodeficiency and aging. A simpler and broader definition which has been proposed is that they are non-obligate and/or non-specialists (i.e. generalists) of a focal host. In the case of plant pathogenic bacteria, the meaning of the term "opportunism" is not clear. In a recently published list of the 10 most significant and economically important plant pathogenic bacteria, more than half are considered to be opportunistic. The medical definition can be applied to some plant/bacterium interactions. When the host is "unwell" due to either environmental stresses or biotic agents, they are more vulnerable to infection. However, there is limited research on the combined effect of abiotic stress factors and bacterial infection of plants. By their nature bacterial pathogens cause disease symptoms under ideal environmental conditions, when a susceptible host is present and when they are able to breach the host surface barrier, i.e. they use an opportunity to infect their hosts. As these bacteria are known to only infect their hosts through wounds and natural openings ("the opportunity"), does this then imply that they are all opportunistic pathogens? Or, is the term restricted to generalists, i.e. those bacteria capable of infecting numerous plant species? Or, does it refer to those that live harmoniously with their host or even exploit an entirely different environment and under "certain" conditions cause disease symptoms? As part of my sabbatical I attempted, by writing a review paper, to define what is meant by opportunistic plant pathogenic bacteria.

Dr. Albé van der Merwe

Host: Prof. Pedro Crous, Dr. Ewald Groenewald and Dr. Lorenzo Lombard

Location: Evolutionary Phytopathology Group, Centraalbureau voor Schimmelcultures (CBS), Utrecht, The Netherlands

Duration: 1 October 2013 to 30 April 2014

Objectives:

- Establish new collaborations between FABI and CBS.
- Nurture existing collaborations between FABI and the CBS.
- Become involved in the research conducted in the Evolutionary Phytopathology Group.
- Perform PCR and sequencing of phylogenetic markers for the *Cryphonectriaceae*.
- Write a review paper on the challenges of fungal species identification.

The Centraalbureau voor Schimmelcultures (CBS) is the preeminent Institute for research on all aspects of fungal biology, including species recognition, phylogenetics, molecular biology and industrialisation of important fungal products. In the Evolutionary Phytopathology Group, headed by Prof. Pedro Crous, the emphasis is on discovering and quantifying fungal species diversity by using modern molecular techniques such as gene and genome sequencing, and complicated algorithms to extract the phylogenetic signal from such data. Additionally, some students in the group are interested in the population genetics of fungi, and use polymorphic microsatellite markers and equally complicated algorithms to assess the frequencies of alleles in populations.

The primary objective of Albé's sabbatical visit to the CBS was to become involved in the research done in the Evolutionary Phytopathology Group and thus to expand his horizons with regard to data acquisition, analysis, and interpretation. To achieve this goal, he embarked on selecting a subset of isolates representing the *Cryphonectriaceae* from the extensive collection housed at the CBS. DNA was extracted from these type isolates (i.e. isolates that carry the names of species), and five gene regions were PCR-amplified and sequenced using the streamlined protocol implemented by Prof. Crous's group. An impressive amount of data were gathered in just seven months, and these data are currently being analysed.

Albé was also fortunate to be able to contribute to several on-going projects in the Evolutionary Phytopathology Group, and these collaborations will become increasingly important in the future. For example, he performed some of the data analyses required for two papers that he recently co-authored with Dr. Lorenzo Lombard and his co-workers, and also aided in the analysis and interpretation of microsatellite data from Dr. Joyce Woudenberg's project. These collaborations already resulted in three published papers.

Albé's secondary objective was to finish the writing and editing of a review paper on the identification of fungal species, focusing on the filamentous Ascomycetes. Although he was unable to finish this objective during the period of the sabbatical, the paper has benefited from valuable insights by his hosts. This review will thus be submitted for publication shortly.

Wilhelmina Park near the University of Utrecht's international student accommodation.

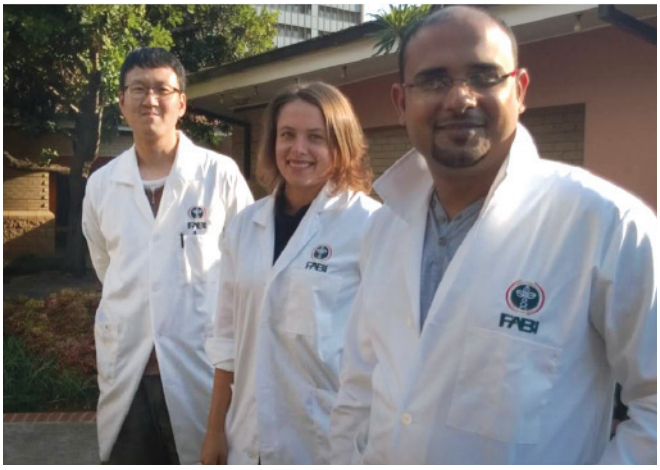
SERVICES

TREE HEALTH EXTENSION

Responsible researchers: Prof. Jolanda Roux (Extension, monitoring, diagnostic clinic)
Prof. Mike Wingfield
Ms. Izette Greyling (Extension and diagnostic clinic)
Dr. Brett Hurley (Pest monitoring and extension)
Dr. Jeff Garnas (Entomology and diagnostics)
Dr. Wilhelm de Beer (Treehealthnet and FABI website)
Ms. Izette Greyling (Extension and diagnostic clinic)
Mr. Darryl Herron (Diagnostic clinic)

OBJECTIVES:

Extension activities form an important component of the Tree Protection Co-operative Programme (TPCP) and DST-NRF Centre of Excellence in Tree Health Biotechnology (CTHB). These activities are divided into a number of components. They include all activities linked to the monitoring of pests and diseases of native and plantation trees. Furthermore, they form an important component in the training of postgraduate students and the creation of tree health awareness amongst the general public, foresters, farmers and conservation staff. Monitoring includes efforts to detect new pathogens and pests in a timely fashion and the evaluation of the change in status of pathogens and pests, which have been present for many years. One of the key components of the monitoring programme is the diagnostic clinic that provides one means of rapid detection of new diseases and pests. Data from the clinic and field extension/monitoring activities also form part of a longer term historical record of pests and diseases in South Africa and many other countries where the teams work.



Diagnostic clinic members of 2014: DongHyeon Lee, Simone Fouche and Tanay Bose.

EXTENSION ACTIVITIES 2011/12

The extension services of the TPCP and CTHB programmes are managed via a broad range of mechanisms. These include lectures presented at field days, such as those organised by the ICFR, NCT and other stakeholders, reports in magazines and newspapers, radio and television interviews, information on the website, newsletters such as Tree Health News and via routine field visits. The extension services are closely linked to the pest and disease diagnostic clinic. Thus, where samples are sent to the clinic for diagnoses, follow-up visits to the field to inspect problems first hand are common. This forms part of an extensive network used to monitor the health of plantations and native forests.

Field visits to plantations and forests by TPCP/CTHB staff and students remain one of the most important components of these programmes. Field trips include those specifically to provide extension lectures, those that are associated with the diagnoses of pests and diseases, as well as those that are linked to field research work of students. In 2013 the

Ginna Granados, Angel Maduke, Tanay Bose and Darryl Herron, members of the diagnostic clinic, during a field consultancy.

Dr. Alistair McTaggart of FABI discussing rust fungi and their impact with members of the ICFR and NCT during a disease consultancy visit.

group spent 1051 person days in field with the number of person days increasing to 1086 in 2014. This represents the presence of members of the TPCP/CTHB research teams in the field virtually every week of the year. Several research projects and publications in ISI rated journals emerged from extension visits undertaken in 2013 and 2014.

The e-mail list server TreeHealthNet has continued to grow and has become a major base for communication between the TPCP and CTHB teams and their forestry stakeholders. The list server is used to announce field trips, such that stakeholders are able to make easy contact with team members traveling to the field, and feedback on new discoveries can be rapidly disseminated using this mode of communication. The server currently connects more than 800 foresters and it is anticipated that it will grow in importance in future. We, therefore, encourage all foresters and conservationists in South Africa to join. This is simply achieved by writing a note to Wilhelm de Beer (wilhelm.debeer@fabi.up.ac.za) and being listed on TreeHealthNet@kendy.up.ac.za.

Like TreeHealthNet, the TPCP and CTHB web pages form an extremely important part of the portal of communication between the Programme and its members. All Newsletters of the TPCP/CTHB are posted on the website and all disease diagnostic aids can also be found there. This is a major source of information for members and it is being very actively used. The TPCP and CTHB sites can be accessed via the FABI site at www.fabinet.up.ac.za. Once listed, it is possible for any member to write a message and this will reach all other members.

The newsletter of the TPCP and CTHB programmes, "Tree Protection News", represents an important means of distributing new information to members. Two issues of the newsletter are distributed annually, via TreeHealthNet. All issues of the newsletter can also be found on our webpages. In addition to Tree Protection News, articles have regularly been produced for magazines or newspapers to inform foresters and the public of our activities.

DIAGNOSTIC CLINIC

The insect pest and disease diagnostic clinic provides an important service to the members of the TPCP and CTHB. This service is actively used and, as mentioned previously, it also provides one of the mechanisms by which new pest and disease problems emerging in plantations and native forests can be identified rapidly. The clinic received a total number of 1753 samples in 2013 and 1470 in 2014.

Dr. Martin Coetzee, Prof. Mario Rajchenberg and PhD student Michel Tchotet of FABI discussing wood rot issues with Dr. Wessel Vermeulen of the South African National Parks Board during a visit to the Garden Route National Park.

PINE PITCH CANKER SCREENING FACILITY

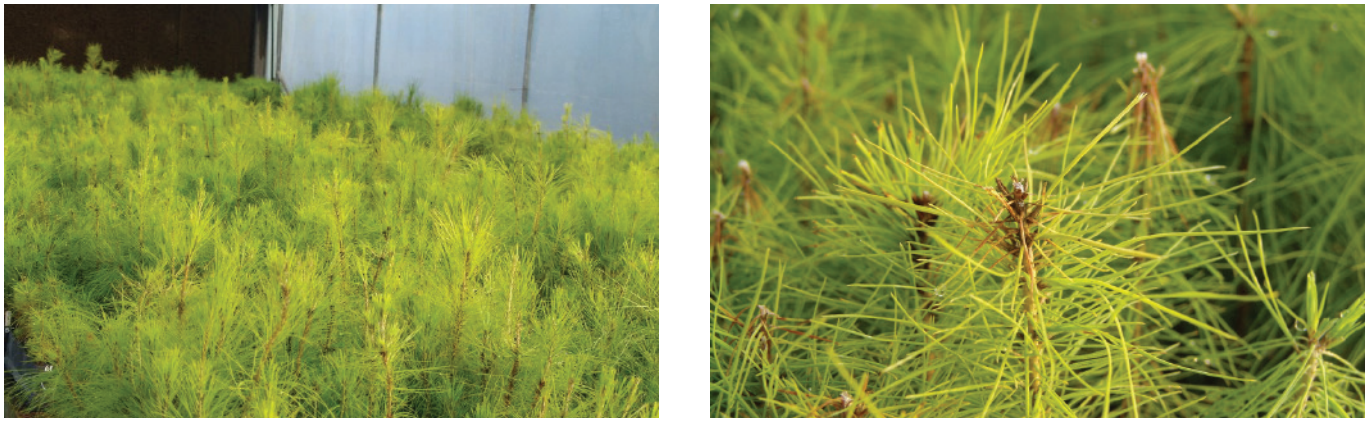
Facility management team: Prof. Emma Steenkamp
Prof. Mike Wingfield

Technical manager: Dr. Fahimeh Jami

Technical committee: Mr. André Nel (Sappi Forests)
Dr. Kitt Payne (Mondi)
Mr. Phillip Hlongwane (KLF)
Mr. Glen Mitchell (York Timbers)
Ms. Lizette de Waal Mitchell (York Timbers)
Ms. Ilse Botman (PG Bison)
Mr. Pieter de Wet (PG Bison)
Dr. Johan de Graaf (Hans Merensky)
Dr. Steve Verryn (Hans Merensky)

In 2005 a collaborative project was launched by Sappi Forests, Mondi Business Paper and Komatiland Forestry to have their pine breeding stock screened for tolerance to the pitch canker fungus, *Fusarium circinatum*. This project is conducted in the Pitch Canker Screening Facility next to the FABI Biocontrol Centre on the University of Pretoria's Experimental Farm. Dr. Fahimeh Jami is the technical manager of the facility.

Twice every year, between 25,000 and 30,000 seedlings and/or cuttings are inoculated with the pitch canker fungus. For this purpose, a standardised method developed at FABI is used. After six weeks of incubation in this greenhouse facility, lesion development is measured. The various forestry companies then analyse the performance of their seedlings/cuttings to inform their pine breeding programmes.



Pine seedlings/cuttings in the Pine Pitch Canker Screening Facility. Left: healthy seedlings before inoculation with *Fusarium circinatum*. Right: close-up of seedlings which shows the progression of disease from the point of inoculation with the pathogen.

FABI postgraduate students in the process of inoculating pine seedlings (left) with *Fusarium circinatum* and recording lesion lengths (right).

ION TORRENT SEQUENCING FACILITY

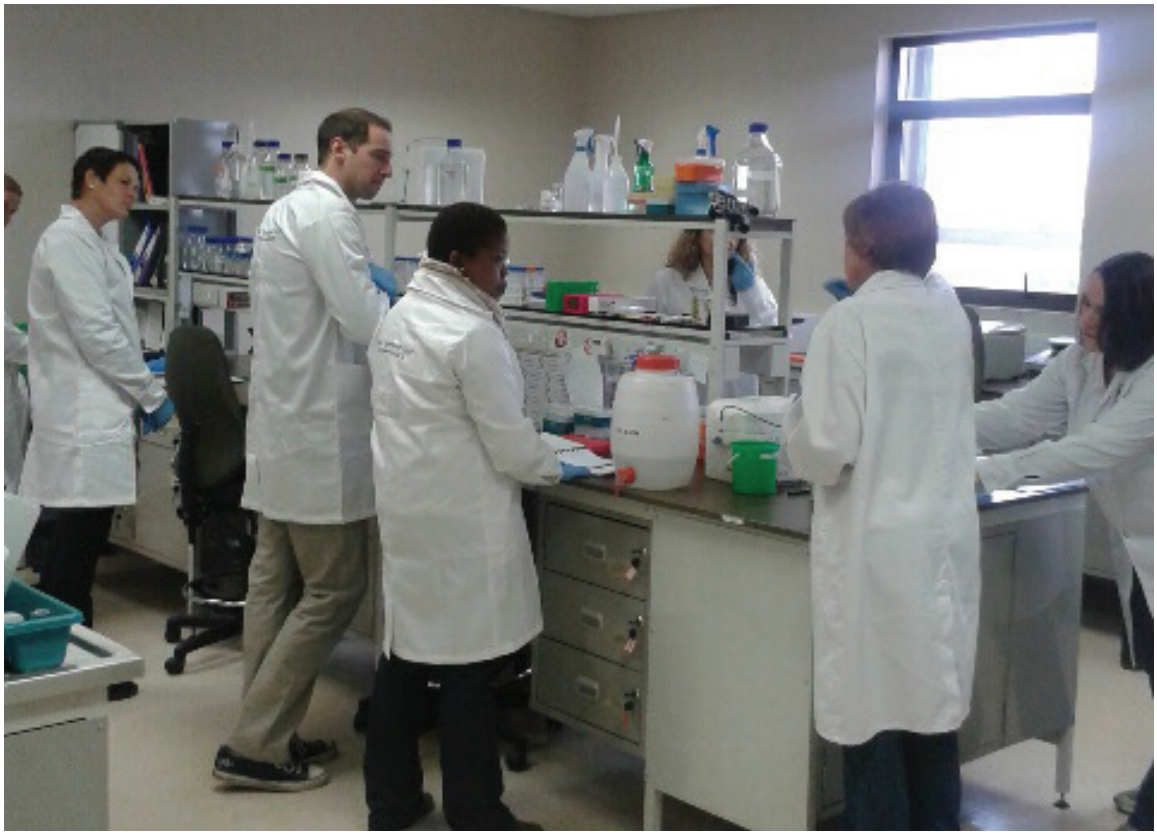
Facility director: Prof. Brenda Wingfield

Facility staff: Mr. Nicky Olivier
Ms. Renate Zipfel
Dr. Elritha van Zyl (to December 2013)
Ms. Busi Zondi (to December 2014)
Ms. Mmatshepho Phasha (From April 2015)

The Ion Torrent Sequencing facility at the University of Pretoria provides high-quality high-throughput sequencing solutions to researchers in South Africa. The Ion Torrent Personal Genome Machine (PGM) housed in a dedicated laboratory in the new Plant Sciences Complex is capable of generating up to 1.5GB sequence data from single or multiplexed samples. Average single-end reads of ~400bp are produced, and the data is utilised for a variety of research questions. The sequencing technology relies on the detection of pH differences during base incorporation at up to 11 million sites on the sequencing chip surface, and achieves a base-calling success-rate of at least 99%. The data quality and output of the Facility has been exceptional, and the Facility currently occupies three positions on the world-wide Top 10 leaderboard for sequence output on the Ion Torrent PGM sequencing platform. Two dedicated technicians have been of critical value in the sequencing activities. Dr Elritha van Zyl (2012-2013) and Ms. Busi Zondi (2014) helped to establish and advance the quality of the sequencing output, while Ms. Mmatshepho Phasha has been active since April 2015.

The managers of the Facility believe strongly in student training and capacity building in next-generation sequencing, and students are encouraged to attend project planning sessions with their supervisors to understand the complex planning process for optimal sequencing results in their respective sequencing projects. To date the Facility has produced whole genome, targeted amplicon and metagenomic sequencing for viral, bacterial, fungal and human samples. To increase the applications offered, the Facility entered into a co-operation agreement with the University of Stellenbosch to sequence transcriptomes and larger genomes from 2015. Users of the Facility include researchers from the Faculties of Natural and Agricultural, Health and Veterinary Sciences, and also the University of the Free State.

During 2014 the Facility hosted a PGM School in conjunction with Life Technologies. This was a unique opportunity for eight researchers to perform a full sequencing work-flow to better understand the next-generation sequencing process. The workshop was also an ideal opportunity for discussions on new projects and applications, and additional seminars on the basics of the technology and data analysis was well attended by other researchers at the University and other Institutions. These highly over-subscribed and very necessary workshops will become an annual fixture in the calendar of the Ion Torrent Sequencing Facility.



Attendees of the inaugural PGM School in 2014
being assisted by Dr. Elritha van Zyl (second from right).

MICROARRAY SERVICE

Facility manager: Prof. Dave Berger

Microarray scientific officer: Mr. Nicky Olivier

The African Centre for Gene Technologies (ACGT) Microarray Facility has a good track record in providing microarray services for researchers throughout Africa, including FABI (see Web of Science citation graph below). Traditionally whole genome microarray studies were confined to model organisms for which well annotated genome information and sequences were available. Researchers were often forced to perform cross-species hybridisations and take species-specific gene composition and sequences into account, or had to rely on cDNA libraries spotted on glass slides. Due to the relatively low cost of generating genomic or transcriptomic sequence data from any organism, the use of microarrays to perform transcriptome studies has become easier and more representative of the specific biological system under investigation.

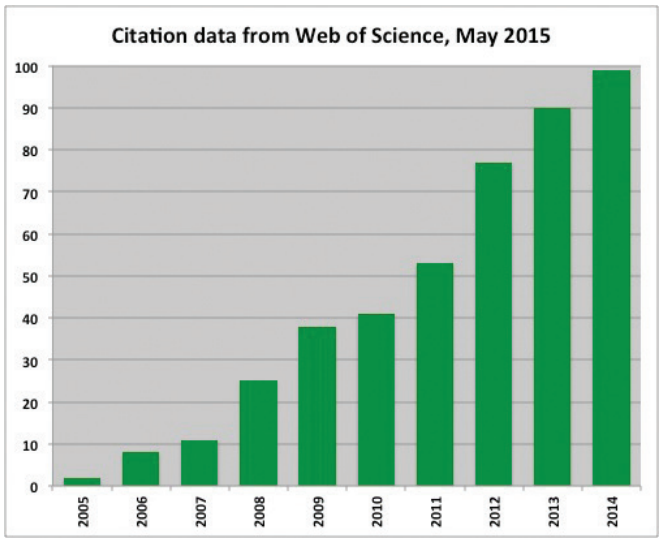
Most current users of the ACGT Microarray Facility make use of the Agilent microarray platform. This enables users to compile a catalogue of sequences to be added to their array (e.g. from genome sequence information), and the free web-based Agilent software computes the most optimal oligonucleotides (60mer) to be synthesised on their slides. Flexible configurations of arrays on the slides with scalable numbers of spots can also be selected, providing a good balance between cost and data throughput. Common formats are 4 x 44,000 or 8 x 15,000 spots per slide. Due to the highly reproducible spot diameters and spot oligonucleotide concentrations, this microarray platform produces high-quality data across multiple experiments.

The ACGT microarray facility houses all the required hardware for processing Agilent slides, along with extensive expertise in experimental design, hybridisation procedures and custom data analysis using open-source software (R and Bioconductor). In addition, the Facility is housed in the Plant Sciences Complex with well-appointed laboratories for RNA isolation and all the required molecular biology techniques. Researchers with limited access to such facilities at their home institutions are accommodated in these laboratories to perform the critical RNA isolations and QC to ensure that the final data is representative of the biological effect under study.

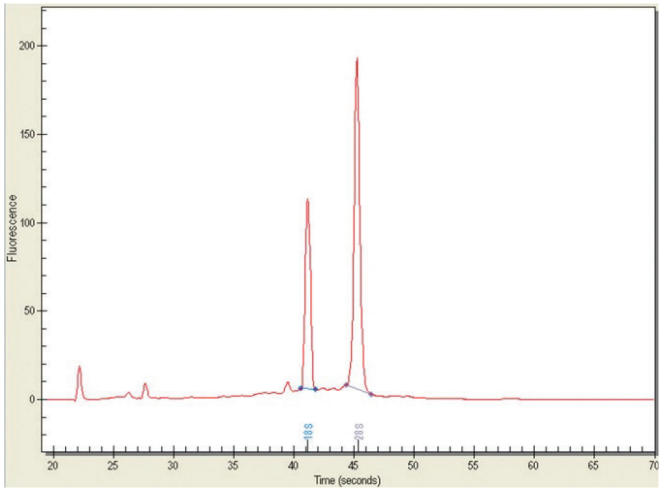
The Facility has not only been of great support to researchers in the Faculty of Natural and Agricultural Sciences, but specifically to FABI. For example, in the last two years four FABI microarray projects have been processed for Prof. Noëlani van den Berg's research group (Fruit Tree Biotechnology Programme), one of these projects in collaboration with Dr Clara Prieto in Spain. These projects have contributed to three student postgraduate degrees, and several research publications.

Since RNA integrity and purity is critical for downstream expression analyses (RT-qPCR, microarrays, etc.) and RNA sequencing applications, the Facility's BioRad Experion automated electrophoresis system is of great importance. The cost-only use of the instrument is not limited to microarray studies, and is available to all interested researchers in the ACGT partner institutions.

For more information, please consult:
http://www.microarray.up.ac.za/



Web of Science citations for microarray publications from the University of Pretoria for the period 2005-2014

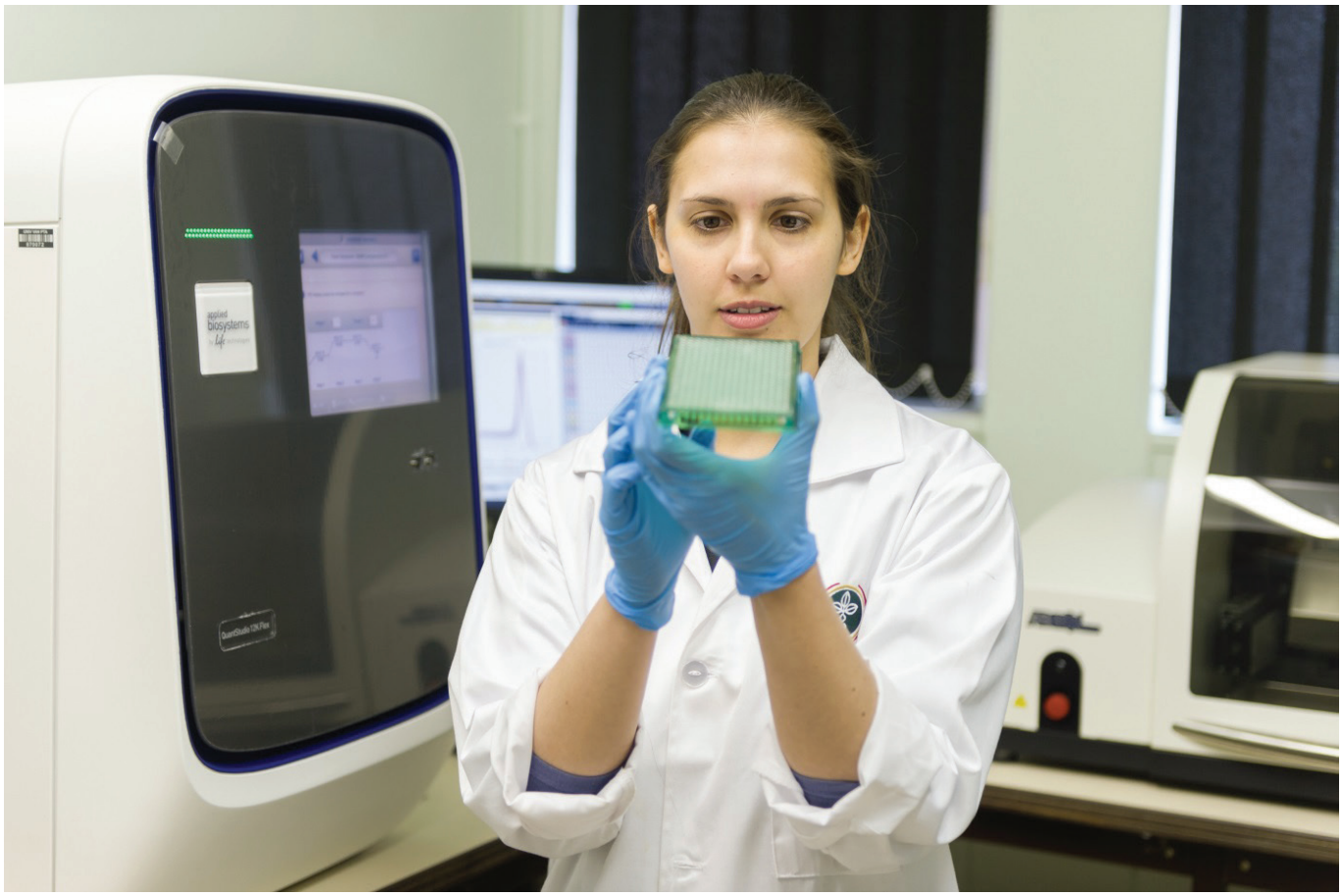


High quality RNA isolated by FABI researchers, analysed on the BioRad Experion system.

QUANTSTUDIO™ 12K FLEX PLATFORM

With support from the NRF National Equipment Platform (NEP) Grant and the University of Pretoria, we have recently established the QuantStudio™ 12K Flex Real-Time PCR facility in FABI. The facility, housed on the sixth floor of the Agricultural Science Building, aims to increase the capacity for quantitative real-time PCR-based research at a national level. The QuantStudio™ 12K Flex instrument is a highly flexible, affordable and efficient platform that supports a wide range of real-time PCR applications such as large-scale gene expression analysis, single nucleotide polymorphism (SNP) genotyping, microRNA and other non-coding RNA profiling, and digital PCR applications.

Ms. Jane Bredenkamp (MSc, Plant Science) is the QuantStudio™ 12K Flex Facility manager, who provides technical support on the instrument and assists researchers with their experimental design. We have negotiated a large discount for first time users of the instrument and we work in close collaboration with Life Technologies specialists who provide support and advice so that each user is able to achieve all their research objectives. For more information please visit the FMG website service page at www.fabinet.up.ac.za/index.php/fm-facilities-services or the Life Technologies website at www.lifetechnologies.com.



Ms. Jane Bredenkamp completing a real-time PCR experiment on the QuantStudio™ 12K Flex Real-Time instrument.

AWARDS & HONOURS

FABI AWARDS FOR EXCELLENCE

Ever since its establishment in 1998, FABI has pursued excellence across its many key performance indicators. This approach has resulted in many accolades for FABI students, academic staff members and for the institute itself. Large numbers of students have thus received prestigious bursaries from various organisations, awards for research excellence and for travel to mention but a few. Likewise academic staff members have received special awards from organisations such as the Department of Water Affairs and Forestry, the Department of Science and Technology, the National Research Foundation, the South African Association for Art and Science, the Royal Society of South Africa, the Academy of Sciences of South Africa and various others. Against this background of excellence, the FABI management decided to institute a suite of awards to be made annually to exceptional FABIans and FABI stakeholders.

FABI awards were presented for the first time in 2007 and these have come to be recognised as important and highly prized. The FABI awards are as follows:

Best FABI student publication

Given the importance of research quality in FABI, one award recognises the best publication produced by a FABI student in the award year. The recipient in the case of this award is chosen based on the ISI impact factor of the paper produced.

2013 Liesl van der Linden, Jane Bredenkamp (joint award)
2014 Ritesh Mewalal

Best FABI M.Sc. thesis

This award is given to an M.Sc. student who achieved the highest mark through external examination of a thesis.

2013 Ronel Viljoen
2014 Marieke du Plessis

FABI award for mentorship

M.Sc. or PhD student who has demonstrated outstanding mentorship, in the broad sense, to other students.

2013 Chrizel Beukes, Ritesh Mewalal, Darryl Herron, Michael Mbenoun, Annie Chan, Felix Fru
2014 DongHyeon Lee, Mmatshepo Phasha, Stephen Taerum, Steven Hussey

FABI award for "getting the message to the public"

This award goes to a student who has excelled in transferring the FABI Science message to the public. Tangible evidence of transferring the accomplishments of FABI, or the science conducted by FABI or its members to the public must be demonstrated.

2013 Amy Wooding
2014 Teboho Letsoale, Kay Bophela, Godfrey Kgatle, Juanita Avontuur

FABI award for recognising contributions by a member of staff of the University

This award is made to a member of staff of the University of Pretoria that has provided exceptional support to FABI.

2013 Allan Hall
2014 Jaywanti Pillay

FABI award for recognising contributions by a person external to the University

This award acknowledges the exceptional contributions to FABI by a stakeholder external to the University of Pretoria. Selection of the recipient is made by the FABI community.

2013 Dr Arlene Bailey (Sappi) and Prof. Stefan Neser
2014 Dr Rikus Kloppers and Mr Felix Middleton (PANNAR) (joint award)

FABIan of the year

This is FABI's premium award for students and it recognises excellence across a broad range of contributions including research, mentorship, support to the maintenance of the structures of the Institute and others. The recipient is chosen by FABI students.

2013 Markus Wilken
2014 Ritesh Mewalal

FABI Photographic Awards

Two awards will be made annually for photographs judged to be the best in their category. These categories include:

Best photograph illustrating a FABIan or FABIans at work

2013 Nanette Coetzer
2014 Jolanda Roux

Best photograph illustrating FABI Research

2014 Ludwig Eksteen

AWARDS TO MANCOM MEMBERS

Prof. Brenda Wingfield

Prof. Brenda Wingfield was awarded the Christiaan Hendrik Persoon Medal during the awards ceremony at the 49th biennial Congress of the Southern African Society for Plant Pathology (SASPP) in Bloemfontein on January 22nd. This gold medal is the highest award that the SASPP can make to one of its members. The award honours the famous mycologist Christiaan Hendrik Persoon (1761-1836) who was born in the Cape Province of South Africa before being sent to Europe at the age of 13 to pursue his education and later to be recognised as one of the 'fathers of mycology.' The Persoon medal was first presented to the globally recognised epidemiologist and member of the SASPP, Dr J.E. van der Plank in 1979. Subsequent recipients include Prof. W.F.O. Marasas (1987), Prof. M.J. Wingfield (1999), Prof. P.W. Crous (2005), and Prof. Z.A. Pretorius (2009). Brenda Wingfield received the award for her outstanding contributions to Plant Pathology. This is only the sixth time that the award has been made in 53 years and Brenda Wingfield is the first female member of the SASPP to receive this honour.

In receiving the Persoon Medal, Brenda Wingfield is recognised as a plant pathologist of substantial international standing, having been an active member of the SASPP (an affilate of the International Society for Plant Pathology) for two decades. Importantly, in this time she contributed substantially to plant pathology in South Africa and also globally. Perhaps the clearest view of these contributions are seen via the fact that she has been a supervisor of some of South Africa's most active and best recognised scientists working with plant pathogens, and numerous of these, including a past President of the SASPP, are now working in countries beyond the borders of South Africa.

Prof. Wingfield with her trophy, together with Dr. Steve Lennon (left), group executive of Eskom, and Minister Naledi Pandor of the Department Science and Technology (right).

FABI was once again in the limelight at the 2013/14 NSTF-BHP Billiton gala dinner and awards ceremony. This amazing function, hosted by the National Science and Technology Forum (NSTF), is often referred to as the South African Science "Oscars". Top Science and Technology leaders and captains of industry are acknowledged here for their contributions to science in this country. Prof. Brenda Wingfield received one of the highly recognised awards for her outstanding contribution to SET through research capacity development over the last 5 to 10 years. Brenda is one of the 12 PhD-level leadership team of the Tree Protection Co-operative Programme (TPCP) and NRF-DST Centre of Excellence in Tree Health Biotechnology (CTHB) and has played a leading role in tree disease research and in building FABI.

Prof. Jolanda Roux

Jolanda Roux received the International Union of Forestry Research Organisations (IUFRO) Scientific Achievement Award at the 2014 IUFRO World Congress in Salt Lake City. This is IUFRO's top award, made to only nine researchers every five years. Jolanda's award recognised her outstanding contributions to Tree Health Research.

Prof. Terry Aveling

Prof Theresa (Terry) Aveling from the University of Pretoria's Department of Plant Science received the 2015 "SANSOR-Bayer Science for a Better Life Award". The prize is awarded by the South African National Seed Organisation and Bayer CropScience in recognition of leadership, innovation and positive contributions to the South African seed industry and agriculture.

Terry established the Seed Science Research Unit that is now internationally recognised and locally relevant through the University of Pretoria Seed Science industry course, post graduate, training and research. Her team plays a pivotal part in a global coordinated multidisciplinary effort to manage seed-borne diseases. The students are trained according to the methods of the International Seed Testing Association (ISTA), that is responsible for standard procedures for testing seeds adopted internationally for the movement of seeds in international trade. Terry served ISTA as vice-chairperson of the Storage Committee (2001-7), member of the Seed Health Committee (2001-7), member of the Rules Committee (2007-13) and chairperson of the Seed Health Committee for the two periods. In 2013, she took up the vice-chair position in order to focus on her role of Chairman of the Seed Pathology Committee of the International Society for Plant Pathology (2013-2018).

Prof. Terry Aveling with her award.

Prof. Mike Wingfield Appointed IUFRO President

FABI Director, Professor Mike Wingfield was appointed as the President of The International Union of Forest Research Organizations (IUFRO) in October 2014. IUFRO's International Council elected him during a meeting at the 24th IUFRO World Congress, in Salt Lake City, Utah, United States.

Prof. Wingfield has been involved in IUFRO activities for more than 30 years and previously served as IUFRO Vice President in the 2010-2014 Board Term. He says that IUFRO - the only worldwide organisation devoted to forest research and related sciences - had deeply enriched his life. It is his wish that the same will be true for others, particularly for the many young forest scientists in the world. He particularly highlighted IUFRO's special relationship with the International Forestry Students' Association (IFSA) and his commitment to build this bond as actively as possible in the future. Furthermore, Prof. Wingfield referred to IUFRO's great responsibility to provide solid and reliable data that will underpin some of the most important decisions relating to our fragile and highly threatened world. He underlined the essential role of forests for a sustainable future of our planet stating that never before has the world relied so heavily on its natural resources and forestry links these resources in every possible way.

Mike being awarded Presidency of IUFRO.

WORKSHOPS AND CONFERENCES

49th CONGRESS OF THE SOUTHERN AFRICAN SOCIETY OF PLANT PATHOLOGY

The 49th biennial Congress of the Southern African Society for Plant Pathology, organised by the University of the Free, was held in Bloemfontein from 19-21 January 2015. The highly successful congress was attended by 202 delegates from seven countries and accommodated 68 oral and 80 poster, high quality presentations. In his opening address Dr. John Purchase, CEO of Agbiz in Pretoria, shared his thoughts on current challenges in South African agriculture and emphasised the important role of plant pathologists in food security, both locally and throughout the southern African region. The thought-provoking Vanderplank and Ethyl M. Doidge Memorial Lectures were delivered by Dr. Sandra Lamprecht (ARC-PPRI Stellenbosch) and Dr. Conrad Schoch (NCBI, Maryland, USA), respectively. The topic of Dr. Lamprecht's presentation was "Confessions of a serial soilborne plant pathologist – 30 years of digging holes, and finding my way out of them". Dr. Schoch addressed the issue of "Do names still matter for fungi?". Additional keynote lectures were given by Dr. Paul Fourie (Citrus Black Spot: a scientific and political conundrum.), Prof. Mike Wingfield (Global Tree Health: New developments and emerging challenges) and Dr. Gary Harman (Emerging opportunities for use of plant beneficial microbes: demystifying the interaction between beneficial microbes and plants). Technical sessions covered ecology and epidemiology, pathogen identification and genetics, various aspects of disease management, and mycotoxins. Concurrent workshops on fungicide application technology and new technologies for identifying fungi were well attended. A lively evening social programme complemented the scientific sessions and several members of the society were honoured at a gala dinner held in the Centenary Hall on the UFS campus i.e. Prof. Brenda Wingfield (C.H. Persoon gold medal), Dr. Sandra Lamprecht (Fellow of the Society), Dr. Bradley Flett (Applied Plant Pathology Award), Dr. Gideon van Zyl (Mildenhall Award) and Palesa Madupe (BSPP Grace Waterhouse Fellowship). The honours in the student oral and poster competitions went to I.L. du Plessis and A. Baloyi respectively, both from Stellenbosch University.

PHYLOGENETIC WORKSHOPS

The Phylogenetic Workshops presented under the auspices of the CTHB focus on the theoretical and applied aspects of contemporary methods used to infer phylogenetic relationships amongst organisms. The importance of these workshops, within the CTHB context, stems from the fact that understanding phylogenetic relationships is an essential aspect of pest and pathogen identification and management. The workshops were initiated in 2004 following the realisation that most researchers have limited experience in the practical application of evolutionary models and tree building algorithms as well as the execution of computer software used for the analyses. A major objective for the workshops has been to provide "hands-on" experience in the use of databases available on the world-wide-web and the range of software, both commercial and freeware, currently available for evolutionary biologists. The workshops – designed and presented by Dr. Martin Coetzee – are offered on a yearly basis and cater for researchers ranging from novices to those having advanced background in the field.

Initially, each workshop catered for participants at all levels of experience. Sessions were paced in such a way as to ensure that the most inexperienced participants were able to keep up. It soon became evident however, that this format allowed insufficient time for providing researchers with an in-depth knowledge regarding phylogenetic theory and hands-on experience in phylogenetic software. In 2009, the workshops were therefore split into separate introductory- and advanced-level sessions.

The introductory-level phylogenetic workshop provides a basic understanding of various phylogenetic techniques, from inspecting a sequence to constructing a tree. The instruction format is a mixture of presentations, exercises and discussions. Dr. Jane Wright, who was previously a post-doctoral Fellow in the CTHB, is contracted annually in a joint venture between the CTHB and Inqaba Biotechnical Industries to steer the workshops.

The advanced-level phylogenetic workshop focuses on advanced phylogenetic concepts and methods, and builds on the concepts introduced during the introductory-level workshops. Phylogenetic methods covered during this workshop include parsimony, maximum likelihood and Bayesian inference of phylogenies, hypothesis testing and molecular clock dating. The instruction format of this workshop is similar to the introductory-level workshop. The advanced-level phylogenetic workshop is presented biannually over five days under the leadership of Dr. Martin Coetzee and assisted by Dr. Jane Wright and Ms. Marika Palmer.

Since the introduction of the phylogenetic workshops, until 2014, 244 researchers have been trained. Of these, 122 participants were students and academic staff associated with the CTHB and TPCP. The remainder were from other research programmes at the University of Pretoria and elsewhere in South Africa, as well as countries in Africa, Asia, Australia. Europe, North America and South America

PHYLOGENOMICS WORKSHOP

Phylogenomics is a relatively new field in biological sciences that combines genome data and evolutionary reconstruction. In a phylogenenomic study, phylogenetic trees are constructed based on comparisons between entire genomes or large portions of genomes. Different to phylogenetics, phylogenomics does not only consider the evolutionary relationships of organism, but also the evolutionary pathways of genomes. With the increasing number of fungal genomes being sequenced at FABI and interest in using these genomes

for phylogenetic studies, a Phylogenomics Workshop was introduced in 2014.

The first Phylogenomics Workshop at FABI was presented from 17-21 November 2014. This was the first time that such a workshop was presented at the institute, and, as far as we know, the first in South Africa. The workshop was coordinated by Dr. Martin Coetzee, and presented by Lisa Barrow (Florida State University, USA), Marike Palmer (CTHB, UP) and Dr. Alastair Potts (Botany Department, Nelson Mandela Metropolitan University). Lisa gave an overview of new technologies for generating genome data, and how these can be applied in phylogenetic, phylogeography and population studies. Marike dealt with hands-on tools to conduct phylogenomic studies, while Dr. Potts presented and gave training in using phylogenetic networks. The workshop was attended by a selection of post-doctoral Fellows and PhD students, all conducting their research at FABI.

JOINT SASBI-SAGS CONGRESS 2014

The 2nd Joint Congress of the South African Society for Bioinformatics (SASBi) and the South African Genetics Society (SAGS) was held from 23-26 September 2014. The Joint SASBi-SAGS Congress was hosted by the University of Pretoria (organised by Prof. Zander Myburg and members of both societies) and was held off-campus at the beautiful Kwalata Game Ranch north of Pretoria. The biennial SASBi and SAGS congresses are the premier national scientific meetings uniting scientists working in the overlapping disciplines of bioinformatics and genetics in South Africa. The joint congress provided an exciting opportunity to learn about cutting-edge research in both disciplines, and to network with members of the two societies and with six leading international scientists who were invited as plenary speakers (Dr. Katherine Denby from University of Warwick, UK; Prof. Pedro Crous from BS-KNAW Fungal Biodiversity Centre, Netherlands; Prof. Rasmus Nielsen from UC Berkeley, USA; Prof. Yves van de Peer from Ghent University, Belgium; Dr. Jerry Tuskan from Oak Ridge National Laboratory, USA; Prof. Chandra Verma from the Bioinformatics Institute, Singapore and Prof. Mikhail Gelfand from Moscow State University, Russia). The theme was “Beyond genes and genomes” with an emphasis on the integration of diverse biological data to understand the function and evolution of biological systems from single gene to whole-genome levels. The African Centre for Gene Technologies (ACGT) in conjunction with UP’s Genome Research Institute (GRI) hosted a pre-Congress Genome Annotation Workshop at the University of Pretoria from 15-19 September 2014. The workshop focussed on MAKER annotation software and was presented by Prof. Mark Yandell and Dr. Barry Moore from the University of Utah.

PUBLICATIONS 2013-2015

These lists include only publications that had appeared by the end of May 2015. Manuscripts in press and submitted for publication are not included.

BOOKS

MARASAS WFO, MARASAS HM, WINGFIELD MJ & CROUS PW (2014) Philatelic Mycology: Families of Fungi**.** CBS Biodiversity Series 14. CBS-KNAW Biodiversity Centre: Utrecht, The Netherlands.

SEIFERT KA, DE BEER ZW, WINGFIELD MJ (2013) The Ophiostomatoid Fungi: Expanding Frontiers*.* CBS Biodiversity Series 12. CBS-KNAW Biodiversity Centre: Utrecht, The Netherlands. 337 pp.

CHAPTERS IN BOOKS AND SYMPOSIUM PROCEEDINGS

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DE BEER ZW & WINGFIELD MJ (2013) Emerging lineages in the *Ophiostomatales*. In: *The Ophiostomatoid fungi: Expanding frontiers* (Seifert KA, ZW De Beer and MJ Wingfield, eds). *CBS Biodiversity Series.* CBS, Utrecht, The Netherlands: 21-46.

DE BEER ZW, SEIFERT KA & WINGFIELD MJ (2013) A nomenclator for ophiostomatoid genera and species in the *Ophiostomatales* and *Microascales*. In: *The Ophiostomatoid fungi: Expanding frontiers* (Seifert KA, ZW De Beer and MJ Wingfield, eds). *CBS Biodiversity Series.* CBS-KNAW Fungal Biodiversity Centre, Utrecht, the Netherlands: 245-322.

DE BEER ZW, SEIFERT KA & WINGFIELD MJ (2013) The ophiostomatoid fungi: their dual position in the Sordariomycetes. In: *The Ophiostomatoid fungi: Expanding frontiers* (Seifert KA, ZW De Beer and MJ Wingfield, eds). *CBS Biodiversity Series.* CBS, Utrecht, The Netherlands: 1-19.

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MOLELEKI LN (2015) *Root knot nematodes and soft rot Enterobacteriaceae, Two emerging problems of potatoes*. (Ed. by Low J., Nyongesa M., Quinn S and Parker M). Potato and Sweet Potato in Africa. Value chain for food and nutrition security. CABI, UK.

NAGEL JH, GRYZENHOUT M, SLIPPERS B, & WINGFIELD MJ (2013) The occurrence and impact of *Phytophthora* on the African continent. In: *Phytophthora*: *a global perspective*. (Ed. by Lamour K), pp. 204-214. CABI, Wallingford, UK.

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VAN WYK M, WINGFIELD BD & WINGFIELD MJ (2013) *Ceratocystis* species in the *Ceratocystis fimbriata* species complex. In: *The Ophiostomatoid fungi: Expanding frontiers*. (Ed. by Seifert K, de Beer ZW, Wingfield MJ), pp. 65-76. Centraalbureau voor Schimmelcultures. Biodiversity Series.

WINGFIELD BD (2013) Fungal Genetics. In: *Brenner's Encyclopedia of Genetics*, 2nd edition, Vol 3. (Ed. by Stanley Maloy and Kelly Hughes), pp. 129-130. San Diego: Academic Press.

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WINGFIELD BD (2014) The ABCs of an NRF rating. *South African Journal of Science* 110: 1-2.

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AHUMADA R, ROTELLA A, SLIPPERS B & WINGFIELD MJ (2013) Pathogenicity and sporulation of *Phytophthora pinifolia* on *Pinus radiata* in Chile. *Australasian Plant Pathology* 42: 413-420.

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C, COIMBRA MRM, COUTINHO LL, DANTAS HL, DE VEGA C, DOS SANTOS CHA, ECHODU R, ENYARU J, FIGUEIRA A, FILHO MAG, FOLTZ B, FRESSIGN L, GADOMSKI EM, GAUTHIER N, HERRERA CM, HYSENI C, JORGE EC, KACZMARCZYK D, KNOTT E, KUESTER A, LIMA APS, LIMA MA, LIMA MP, LONGO ALB, LOR G, MAGGIONI R, MARQUES TS, MARTINS AR, MATOSO DA, MEDRANO M, MENDONC MAC, METTLER AR, NASCIMENTO PMR, NEGRI V, OLIVEIRA KKC, OLIVEIRA LO, OVCARENKO I, PAULA-SILVA MN, RAGGI L, SANDOVAL-CASTILLO J, SCHAEFER HM, SEGELBACHER G, SEINO MM, SISTROM M, TAOLE MM, TESKE PR, TSAGKARAKOU A, VERDADE LM, VILLELA PMS, VINSON CC, WINGFIELD BD & WINGFIELD MJ (2013) Permanent Genetic Resources added to Molecular Ecology Resources Database 1 October 2012-30 November 2012 (2013) *Molecular Ecology* 13: 341-343.

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ROODT D, WILKEN PM, WINGFIELD MJ & WINGFIELD BD (2013) The MAT locus of species within the *Ceratocystis fimbriata sensu lato* complex. 48th Annual Congress of the Southern African Society for Plant Pathology, Bela Bela.

ROUX J & WINGFIELD MJ (2015) Heading for an unknown future: We must do more to protect our native plants from attack by invasive pests and pathogens. Congress of the Southern African Association of Botanists, January 2015, Tshipise, Limpopopo Province.

ROUX J, MCTAGGART A, HERRON D, GREYLING I, FOUCHE S, CHAN J, NORRIS C, MBATHA T, WINGFIELD BD & WINGFIELD MJ (2015) A devastating new rust disease of *Acacia mearnsii* in South Africa. 49th Congress of the Southern African Society for Plant Pathology, Bloemfontein, South Africa.

SANTANA Q, COETZEE M, STEENKAMP ET, WINGFIELD MJ & WINGFIELD BD (2013) Assessment of synteny in the genomes of *Fusarium circinatum* and *Fusarium verticillioides*. 48th Annual Congress of the Southern African Society for Plant Pathology, Bela Bela.

SEALE T, MACRAE SC, STEENKAMP ET, WILSON M, ESPOSITO D, KOMARNYTSKY S, BROZEL VS & VENTER SN (2013) The population structure of *Escherichia coli* associated with freshwater environments. South African Society for Microbiology Congress, Bela-Bela, 24-27 November 2013.

SEREME KT, VAN ZYL E, STEENKAMP ET & VENTER SN (2013) The species description of root nodulating *Burkholderia* associated with indigenous South African legumes: a polyphasic approach. South African Society for Microbiology Congress, Bela-Bela, 24-27 November 2013.

SIBANDA S, THERON J & COUTINHO TA (2013) Functional role of quorum sensing systems in *Pantoea ananatis.* 48th Congress of the Southern African Society for Plant Pathology, ATKV Klein Kariba, January 2013.

SIMPSON MC, COETZEE MPA, WINGFIELD MJ & WINGFIELD BD (2013) Analysis of mating-type switching during meiosis in *Ceratocystis fimbriata*. 18th Biennial Congress of the South African Society for Microbiology, Forever Resorts Warmbaths, Bela Bela, Limpopo, 24-27 November 2013

SIMPSON MC, WILKEN PM, COETZEE MPA, WINGFIELD MJ & WINGFIELD BD (2013) Analysis of microsatellite abundance and distribution in the genome of *Ceratocystis fimbriata*. 48th Congress of the Southern African Society for Plant Pathology, ATKV Klein Kariba, Bela Bela,

SIMPSON MC, WILKEN PM, COETZEE MPA, WINGFIELD MJ & WINGFIELD BD (2012) Development of a diagnostic test to differentiate between cryptic species in the *Ceratocystis fimbriata sensu lato* complex. South African Society for Plant Pathology Northern Branch Postgraduate symposium, University of Pretoria, Pretoria,

SLIPPERS B, DE BEER ZW & WINGFIELD MJ (2013) High throughput taxonomy for fungi: the diminishing value of morphology in describing species. 48th Congress of the Southern African Society for Plant Pathology, Klein Kariba, Bela-Bela, South Africa, 20-24 January 2013.

SLIPPERS B, HURLEY BP, GARNAS J & WINGFIELD MJ (2014) The critical role of quarantine and biological control of forestry pests in a globalised world. South Africa Forestry Conference, Pietermaritzburg, South Africa, 29-30 August.

SNYDERS K & PIETERSEN G (2014) Molecular screening of Rio Red grapefruit for the presence of the T36 genotype of CTV. 8th Citrus Research Symposium, Champagne Sports Resort, Drakensberg, 18 - 20 August 2014.

SWANEPOEL R, POSTMA-SMIDT A, SLIPPERS B, JOUBERT F & YEK SH (2014) Dscam in Hymenoptera Genomes: evolutionary transitions from solitary to eusocial lifestyle. 2nd Joint Congress of the South African Society for Bioinformatics and the South African Genetics Society, Kwalata Game Ranch, Pretoria, South Africa, 23-26 September 2014.

TAERUM SJ, DE BEER ZW, DUONG TA, GILETTE N, SUN JH & WINGFIELD MJ (2013) Post-invasion changes in symbiont assembly of the invasive red turpentine beetle (*Dendroctonus valens*) in China. 48th Annual Congress of the Southern African Society for Plant Pathology, Bela Bela.

TANUI CK & MOLELEKI LN (2015) Charaterisation of the *Pectobacterium carotovorum* subsp *brasiliense* (*Pcb*) expl gene during infection of potato tubers and stems. Southern African Society of Plant Pathologists, University of Bloemfontein, South Africa.

TCHOTET JMT, COETZEE MPA, RAJCHENBERG M & ROUX J (2014) Identification of wood rotting fungi in the Garden Route National Park of South Africa. 20th Association for the Taxonomic Study of the Flora of Tropical Africa (AETFAT) Congress, Stellenbosch, South Africa, 13-17 January 2014.

TERMER K, HURLEY BP & GARNAS J (2013) Biotic and abiotic determinants of resource quality for the European woodwasp, *Sirex noctilio*. XVIII Entomological Society of Southern Africa Congress, Potchefstroom, South Africa, 30 June-3 July 2013.

VAN DER LINDE JA, SIX DL, WINGFIELD MJ & ROUX J (2013) Fungi associated with *Euphorbia ingens* die-offs in South Africa and Zimbabwe. 48th Annual Congress of the Southern African Society for Plant Pathology, Bela Bela.

VAN DER LINDE JA, SIX DL, WINGFIELD MJ & ROUX J (2015) *Cyrtogenius africus* (Scolytinae), its phoretic mites and novel ophiostomatoid partners: the final blow leading to the *Euphorbia ingens* die-off. 49th Congress of the Southern African Society for Plant Pathology, Bloemfontein, South Africa.

VAN WYK S, WINGFIELD BD, DE VOS L, VAN DER MERWE NA & STEENKAMP ET (2015) Diverse origins of genes associated with growth QTL in *Fusarium circinatum*. 49th Annual Congress of the Southern African Society for Plant Pathology, Bloemfontein.

VENTER SN (2013) Implications of environmental *E. coli* in agriculture. Food Safety, Postharvest Technology and Packaging for the Future, Pretoria 20-21 August 2013.

VENTER SN, SEALE T, MACRAE SC, STEENKAMP ET, WILSON M, ESPOSITO D, KOMARNYTSKY S & BROZEL VS (2013) Diversity of *E. coli* associated with aquatic environments. Celebrating the University of Pretoria's water-related knowledge, Pretoria 28-29 October 2013.

VILJOEN E, BERGER DK & REES DJG (2014) Next generation sequencing, assembly and annotation of chloroplasts for phylogenetic analysis of amaranths. SASBi-SAGS Joint 2014 Congress, Kwalata Game Lodge, Pretoria.

VILJOEN R, STEENKAMP ET & PIETERSEN G (2013) Alternative hosts of "*Candidatus* Liberibacter africanus" amongst indigenous members of the Rutaceae in South Africa. 48th Conference of the Southern African Society for Plant Pathology, 20-24 January 2013, Bela-Bela.

VISSER EA, WEGZYN J, STEENKAMP E, MYBURG AA & NAIDOO S (2014) *Pinus patula* transcriptome assembly. South African Genetics & Bioinformatics Society Conference, Kwalata Game Ranch, Tshwane, 23-26 September 2014.

VOSLOO S, MASEKELA R, GREEN R, DE BEER ZW & VENTER F (2013) Microbial diversity in childhood bronchiectasis as revealed by 16S rRNA pyrosequencing. IRT Colloquium day, 8 November 2013, University of Pretoria, Pretoria.

VOSLOO S., MASEKELA R, GREEN R, DE BEER ZW & VENTER SN (2013) Microbial diversity in childhood bronchiectasis as revealed by 16S rRNA pyrosequencing. Genomics Research Institute seminar day, 14 November 2013.

WALSH HA, & PIETERSEN G (2013) Development of a Loop-mediated amplification (LAMP) detection system for Grapevine leafroll associated virus type 3 to contribute to the control of Grapevine Leafroll disease in white cultivars in South Africa. South African Society for Microbiology 2013 Conference. 24-27 November, 2013, Bela-Bela, South Africa.

WELLER-STEWART T, SHYNTUM D, COUTINHO TA, TOTHI & THERON J (2013) Creating *Pantoea ananatis* mutants using λ phage proteins. 48th Congress of the Southern African Society for Plant Pathology, ATKV Klein Kariba, January 2013.

WELLER-STEWART T, TOTH I, THERON J, P DE MAAYER & COUTINHO TA (2015) Mutations of flagella (*flgK* and *motA*) and type IV pili (*pilA* and *pilT*) genes of *Pantoea ananatis* LMG20103 reduces motility, attachment and virulence in onion seedlings. 49th Congress of the Southern African Society for Plant Pathology, Bains Lodge, Bloemfontein 19-21 January 2015.

WIERZBICKI M, MYBURG AA & HUSSEY SG (2014) Validation of custom antibodies for ChIP-seq analysis of transcription factors associated with secondary cell wall deposition in *Eucalyptus*. South African Genetics & Bioinformatics Society Conference, Kwalata Game Ranch, Tshwane, 23-26 September 2014.

WILKEN PM, STEENKAMP ET, DE BEER ZW, WINGFIELD MJ & WINGFIELD BD (2013) Mating in the self-sterile plant pathogen *Ceratocystis fimbriata*. 48th Annual Congress of the Southern African Society for Plant Pathology, Bela Bela.

WOODING AL, WINGFIELD MJ, HURLEY BP, GARNAS J, DE GROOT P & SLIPPERS B (2013) Symbiont switching during the *Sirex noctilio* invasion into Canada. XVIII Entomological Society of Southern Africa Congress, Potchefstroom, South Africa, 30 June-3 July 2013.

ZLATKOVIĆ M, WINGFIELD MJ, JAMI F, KECA N, LAZAREVID J & SLIPPERS B (2013) Diversity of Botryosphaeriaceae associated with the die-back of ornamental trees in Serbia and Montenegro. 48th Congress of the Southern African Society for Plant Pathology, Klein Kariba, Bela-Bela, South Africa, 20-24 January 2013.

ZONDI NBN, CHAN WY, VENTER SN, VAN ZYL E, ZIPFEL RD & OLIVIER N (2014) Optimised library preparation for GC rich bacterial genome sequencing on the Ion Torrent PGM. Ion World 2014 symposium, Cape Town, 2-3 October 2014.

ZWART L, MANGWANDA R, VISSER EA, MYBURG AA & NAIDOO S (2014) Investigating the systemic responses of *Eucalyptus grandis* to infection with *Chrysoporthe austroafricana*. South African Genetics & Bioinformatics Society Conference, Kwalata Game Ranch, Tshwane, 23-26 September 2014.

SEMINAR PRESENTATIONS

All postgraduate students linked to FABI present two seminars each year on a Thursday morning. Special seminars, presented by invited speakers, are also held regularly.

Dr Riekert van Heerden, **South African Sugar Association**
January 2013
Chemical manipulation of sugarcane growth and cane quality – current research in the South African sugar industry

Prof. Michael Poulsen, Department of Biology, Section for Ecology and Evolution, University of Copenhagen, Denmark
February 2013
The genomics of the tripartite symbiosis between termites, fungi and bacteria

Prof. David Hibbett, Clark University, USA
April 2013
Evolution of wood decay in basidiomycetes inferred using comparative genomics

Prof. Mario Rajchenberg, National Scientific and Technical Research Council, Buenos Aires, Argentina
July 2013
Sex, food, behaviour and the phylogeny of polypores

Prof. Treena Burgess, Murdoch University, Australia
October 2013
Eucalyptus species, the perfect host for studying pathogen movement between plantations (native and exotic) and forests

Dr. Rebecca Ganley, SCION, New Zealand
November 2013
Forest pathology, protection and biosecurity in New Zealand

Dr. Carolee Bull, USDA, USA
November 2013
Bacterial taxonomy drives strategies for control of bacterial leaf spot of lettuce caused by *Xanthomonas campestris* pv. *vitians*

Drs. Flora Krivak-Telly and Brian Thompson, Dartmouth University and University of Maryland, USA
December 2013
Intercontinental patterns and microbial symbiosis of a global invasive pest, *Sirex noctilio*

Simon Martin, Cambridge University, UK
March 2014
Of bicycles, beers and butterfly genomes

Dr. Joel Pothier, **ZHAW, Zurich**
April 2014
MALDI-TOF mass spectrometry application for rapid phylogenetic analysis and identification of plant-health relevant bacteria.

Dr. Michelle Greve, **University of Pretoria**
April 2014
A bird's eye view: Biodiversity patterns at large spacial scales

Dr. Peter le Roux, **University of Pretoria**
April 2014
Predicting spacial distribution variation on the outcome in plant-plant interactions

Dr. Rob Jackson, **University of Reading, UK**
May 2014
Mechanisms and adaptations for *Pseudomonas fluorescens* motility and biocontrol

Prof. Dawn Arnold, **University of the West of England, UK**
May 2014
Evolution of *Pseudomonas syringae* pv. *phaseolicola* via genomic island loss and gain

Dr Cristina Marques, **RAIZ, Portugal**
August 2014
AIZ R&D contribution to eucalypt forest productivity in Portugal

Dr Catarina Gonçalves, **RAIZ, Portugal**
August 2014
Integrated pest management at RAIZ

Prof. Pedro Crous, **Centraalbureau voor Schimmelcultures, Netherlands**
August 2014
Are cryptic species real?

Prof. Bitty Roy, **Institute of Ecology and Evolution**
September 2014
Fungal floral mimicry by *Dracula* orchids

Dr. Clara Pliego Prieto, Malaga, Spain
September 2014
Approaches to control and understand the avocado white root rot caused by *Rosellinia necatrix*

Prof. Jeremy Allison, **Pest Ecology and Management team of Natural Resources, Canada**
November 2014
Chemically-mediated inter- and intraspecific interactions

Prof. Salim Abdool Karim, Director of CAPRISA -Centre for the AIDS Programme of Research in South Africa
January 2015
Building CAPRISA: Experiences, successes and frustrations in establishing a world-class medical research centre of excellence

Prof. Koos Boomsma, University of Copenhagen, Denmark
January 2015
Commitment in social life, sex and symbiosis

Dr Adam Konecný, Masaryk University, Czech Republic
February 2015
Approximate Bayesian Computation: a useful approach for inferring population history from genetic data

Prof. Michael Poulsen, **University of Copenhagen, Denmark**
February 2015
30 million years of farming and pharmacy innovation in fungus-growing termites

FABI TEAM 2011-2013

FULL TIME ACADEMIC & RESEARCH STAFF

Prof. Dave Berger
Prof. Teresa Coutinho
Prof. Pedro Crous
Prof. Karl Kunert, Emeritus Professor
Prof. Zander Myburg
Prof. Jolanda Roux
Prof. Bernard Slippers
Prof. Stephanus Venter
Prof. Brenda Wingfield
Prof. Michael Wingfield
Extraordinary Prof. Gerhard Pietersen
Assoc. Prof. Terry Aveling
Assoc. Prof. Lucy Moleleki
Assoc. Prof. Emma Steenkamp
Assoc. Prof. Noëlani van den Berg
Dr. Irene Barnes
Dr. Martin Coetzee
Dr. Bridget Crampton
Dr. Wilhelm de Beer
Dr. Jeff Garnas
Dr. Brett Hurley
Dr. Eshchar Mizrachi
Dr. Kershney Naidoo
Dr. Sanuska Naidoo
Dr. Albé van der Merwe
Dr. Juan Vorster

TECHNICAL STAFF

Mr. Wilton Boyi
Ms. Jane Bredenkamp
Ms. Samantha Bush
Ms. Daphney Chokoe
Dr. Berdine Coetzee
Mr. Jurgens de Bruin
Ms. Minique de Castro
Mr. Ndumiso Dlamini
Mr. Neil de Jager
Ms. Juanita Engelbrecht
Ms. Gerda Fourie
Ms. Christy Garritsen
Ms. Sonica Godard
Ms. Izette Greyling
Ms. Marlene Harney
Ms. Tracey Hatherell
Mr. Hardus Hatting
Ms. Alex Jansen van Rensburg
Ms. L'Zanne Jansen van Rensburg
Mr. Joseph Khadile
Ms. Pritty Khumalo
Mr. Ian Law
Ms. Annelie Lübben
Ms. Grieta Mahlangu
Dr. Soenju Marinkowitz
Ms. Sharon Masipa
Mr. Guelor Mayonde
Ms. Babalwa Mbebe
Mr. Alex Mtuyedwa
Ms. Eva Müller
Ms. Karin Muller
Ms. Valentina Nkosi
Ms. Sophie Nyoni
Mr. Nicky Olivier
Mrs. Marja O'Neill
Ms. Patience Ralikonyana
Ms. Melissa Reynolds
Ms. Maleshoane Selaocoe
Ms. Melissa Turton
Ms. Karen van der Merwe
Mrs. Adri Veale
Dr. Elritha Venter

ADMINISTRATIVE STAFF

Ms. Mmampe Aphane
Ms. Vivienne Clarence (until Dec 2014)
Ms. Elna Cowley
Ms. Helen Doman
Ms. Heidi Fysh
Ms. Jenny Hale (until Dec 2013)
Ms. Adrene Laubsher
Ms. Martha Mahlangu
Ms. Resego Moje
Ms. Marija O'Neill
Ms. Annette Schnetler (untl Jun 2013)
Ms. Madelein van Heerden

INFORMATION SPECIALIST

Ms. Marie Theron (until May 2014)
Ms. Raine van der Merwe

HONORARY PROFESSORS/LECTURERS

Prof. Paul Birch
Prof. Treena Burgess
Prof. Pedro Crous
Prof. Brion Duffy
Prof. Stefan Neser
Prof. Ian Toth
Prof. Steven Verryn
Prof. Xu-Dong Zhou
Dr. Wubetu Bihon
Dr. Sharkei Chen
Dr. Draginja Pavlic

SABBATICAL VISITORS

Dr. Eduard Venter, Dept of Botany and Plant Biotechnology, University of Johannesburg (2013)

Prof. Mario Rajchenberg, National Scientific and Technical Research Council, Buenos Aires, Argentina

UP RESEARCH FELLOWS

Dr. Irene Barnes (until end of 2014)
Studies on *Dothistroma* spp.

Dr. Casper Crous
Ecology of tree decline

Dr. Tuan Duong
Ophiostoma genomics

Dr. Martin Kemler
Host, geography and anthropogenic influences on community composition of endophytes and latent pathogens of trees

Dr. Magriet van der Nest
Ceratocystis genomics

POST-DOCTORAL FELLOWS

Dr. Maryke Carstens
Genomics of quantitative disease resistance in African maize varieties

Dr. Nanette Christie
Transcriptional control underlying wood quality and disease resistance traits in *Eucalyptus* trees

Dr. Lieschen de Vos
Genomes of *Fusarium* species in the *Giberella fujikuroi* complex

Dr. Tuan Duong
Molecular characterisation of *Leprographium serpens*

Dr. Steven Hussey
Transcriptional regulation of wood formation in *Eucalyptus*

Dr. Riikka Linnakoski
Biology and taxonomy of fungal bark beetle associates from Finland and Russia

Dr. Gaby Nkouaya Mbanjo
Genome-wide dissection and molecular breeding of wood property traits in a clonal interspecific backcross population of *Eucalyptus grandis* and *E. urophylla*

Dr. Michael Mbenoun
Diversity and Ecology of *Ceratocystis* species and their nitidulid associates in Africa

Dr. Alistair McTaggart
Rust fungi in South Africa

Dr. Bilal Mir
Expression of recombinant hyperthermophilic enzymes in plant tissues: a novel approach for lignocellulose digestion

Dr. Gilbert Kamgan Nkuekam
Cryphonectriaceae on Myrtales in Hawaii, identification and population diversity

Dr. Lucas Shuttleworth
Botryosphaeriaceae on native Myrtales in Southern Africa

Dr. Sonia Phillips
Genomics of quantitative disease resistance in African maize varieties

Dr. Ashok Prabhu
Unravellng the molecular basis of interaction between avocado-*Phytophthora cinnamoni* interaction through gene silencing

Dr. Bianca Reeksting
Flooding responses in avocado

Dr. Michelle Schroder
Local adaptation to temperature and host in the Eucalyptus snout beetle

Dr. Louise Shuey
Defence responses against *Puccinia psidii* in *Eucalyptus grandis*

Dr. Stephanie Slinski
Characterisation of the *Fusarium circinatum* genome

Dr. Libert Brice Tonfack
Cell wall engineering to improve woody biomass feedstock degradation

Dr. Lydia Wahba
Expression profile for small RNAs for resistant/susceptible root rot in avocado

Dr. Ramesh-Aadi Moolam
Transposon mutagenesis of *Pectobacterium carotovorum* subsp. *brasiliense*

Dr. Maria Vivas
Environmental maternal effects on resistance of *Eucalyptus* to pathogens and the structuring of fungal endophyte communities

Dr. Famimeh Jami
Taxonomy of *Cytospora*

Dr. Tania Weller-Stuart
Virulence factors in *Pantoea ananatis*

Dr. Gudrun Dittrich-Schröder
Diversity and control of *Leptocybe invasa*

Dr. Marc Bouwer
Pheromones of forest insects pests in South Africa

Dr. Miang Yin
Taxonomic studies on Ophiostomatoid fungi

CURRENT POSTGRADUATE STUDENTS

PhD Students

Birhan Abate
Use of entomopathogenic nematodes in plantation forestry
Advisors: B Hurley, B Slippers & MJ Wingfield

Omotayo Adenigba
The role of peptide pheromones in the biology of *Fusarium*
Advisors: ET Steenkamp, NA van der Merwe, MJ Wingfield & BD Wingfield

Teddy Amuge
Gene expression study of interactions between cassava and cassava brown streak disease
Advisors: DK Berger, M Ferguson, J Harvey & AA Myburg

Robert Backer
Isolation and characterisation of non-expresser of pathogenesis related 1 (NPR1) in *Phytophthora cinnamomi* infected avocado (*Persea americana*)
Advisors: N van den Berg & S Naidoo

Kwabena Baffoe
Biological control of *Leptocybe invasa*
Advisors: B Hurley, B Slippers, J Garnas & MJ Wingfield

Tessa Bauman
Associations between fungi and root-infesting bark beetles in the USA and Nicaragua
Advisors: W de Beer & MJ Wingfield

Vaughan Bell
An integrated strategy for managing *Grapevine leafroll-associated virus 3* in red berry cultivars in New Zealand
University of Victoria, Wellington, New Zealand
Advisors: PJ Lester & G Pietersen

Velushka Birkenbach
Study of toxin biosynthesis genes in *Cercospora zeina*
Advisors: DK Berger & BG Crampton

Jonathan Botha
Chimeric enzymes for the *in planta* modification of secondary cell wall biopolymers
Advisors: D Cowan & AA Myburg

Albasini Canico
Impact of intra-guild diversity of *Anaphes* biocontrol of the Eucalyptus snout beetle
Advisors: J Garnas & BP Hurley

Gabrielle Carstensen
Eucalyptus/Ralstonia interactions
Advisors: TA Coutinho, SN Venter & MJ Wingfield

Annie Chan
Evolutionary history of the nitrogen fixation of rhizobial *Burkholderia* species associated with indigenous South African legumes
Advisors: SN Venter & ET Steenkamp

Runlei Chang
Fungal associates of Ips bark beetles in China
Advisors: W de Beer & MJ Wingfield

Magdaleen Cilliers
Soybean nodule development, nitrogen fixation and gene expression under water limiting condition
Advisor: J Vorster

Elsie de Meyer
Fungi associated with *Adansonia digitata*
Advisors: MJ Wingfield, B Slippers & J Roux

Marike du Plessis
Evolutionary approaches to delineate bacterial genera and species
Advisors: SN Venter, ET Steenkamp & MPA Coetzee

Elodie Ekoka
Investigation of putative transporters involved in carbon partition during xylogenesis
Advisors: E Mizrachi & AA Myburg

Berhanu Fenta
Investigation of the physiological responses in soybean and common beans to water deficit
Advisor: J Vorster

Katrin Fitza
The diversity and specificity of the *Deladenus siricidicola-Sirex noctilio-Amylostereum areolatum* complex
Advisors: B Slippers & J Garnas

Arista Fourie
Genetics of host specificity
Advisors: I Barnes, BD Wingfield & MJ Wingfield

Gerda Fourie
A study of virulence of *Fusarium circinatum* from a genomics perspective
Advisors: ET Steenkamp, BD Wingfield & MJ Wingfield

Felix Fon Fru
Field ecology and epidemiology of the pitch canker pathogen, *Fusarium circinatum*, in South African pine plantations
Advisors: J Roux, ET Steenkamp & MJ Wingfield

Mesfin Gossa
Diversity and management of *Pissodes nemorensis*
Advisors: B Hurley, B Slippers & J Garnas

Izette Greyling
Ambrosia beetle associated disease of *Eucalyptus* in South Africa
Advisors: J Roux, W de Beer & MJ Wingfield

Miekie Haasbroek
Identification and functional characterisation of *Exserohilum turcicum* pathogenicity factors
Advisors: BG Crampton & DK Berger

Darryl Herron
The biodiversity of *Fusarium* spp. occurring in the commercial forestry industry
Advisors: ET Steenkamp, BD Wingfield & MJ Wingfield

Zander Human
The ecology of Actinomycetes associated with *Protea*
Advisors: W de Beer, MJ Wingfield & SN Venter

Josephine Jere
Bacterial diseases of potatoes in Zimbabwe
Advisors: J van der Waals & TA Coutinho

Luke Jimu
Diseases of Eucalypts in Zimbabwe with special reference to *Teratosphaeria* spp.
Advisors: J Roux & MJ Wingfield

Delphin Kandolo
Alternaria blight of sweet potato: cultivar resistance, fungicide control an development of IDM strategy in South Africa
Advisors: TAS Aveling, M Truter & J van der Waals

Aquillah Kanzi
Mating systems and the evolution of *Chyrsoporthe* species
Advisors: NA van der Merwe, ET Steenkamp & BD Wingfield

Godfrey Kgatle
Alternaria species on sunflower (*Helianthus annuus* L.) in South Africa: morphological, chemical and molecular characterisation, infection process and control
Advisors: TAS Aveling, M Truter & B Flett

Tsholofelo Kibido
The role of *Rhizobium* strain and soybean cultivar on nitrogen fixation
Advisor: J Vorster

Ilkadim Kiper
Molecular screening for interacting partners of *Phytophthora cinnamomi RxLR* effectors via yeast two-hybrid system
Advisor: N van den Berg

Maytha Deer Konkarn
Taxonomy of bark beetle associated fungi from Thailand
Advisors: W de Beer & MJ Wingfield

Jeanne Korsman
Molecular responses of maize to its foliar pathogen, *Cercospora zeina*
Advisors: DK Berger & BG Crampton

Stanford Kwenda
Differential gene expression analysis of potato genotypes
Advisors: L Moleleki & P Birch

DongHyeon Lee
Pathogenicity of *Ceratocystis albifundus*
Advisors: MJ Wingfield & J Roux

FeiFei Liu
Ceratocystidaceae in China
Advisors: J Roux, MJ Wingfield & S Chen

Brigitte Lombard
Unravelling the sorghum-*Exserohilum turcicum* pathosystem
Advisors: BG Crampton & SL Murray

Joseph Machua
Diseases of Eucalypts in Kenya
Advisors: B Slippers, MJ Wingfield & J Roux

Eugene Makgopa
Production and characterisation of transgenic Arabidopsis and soybean (*Glycine max* L. Merr.) plants overexpressing oryzacystatin-I
Advisor: J Vorster

Mmatlala Mamabolo
Bacterial diseases of Umbrelliaceae in South Africa
Advisors: TA Coutinho, M Truter & T Goszzynska

Ronishree Mangwanda
Investigation into the transcriptional response of *Eucalyptus grandis* against *Chrysoporthe austroafricana*
Advisors: S Naidoo & AA Myburg

Edgar Mangwende
Seedborne pathogens of Eucalypts
Advisors: TAS Aveling & J Roux

Mkhululi Maphosa
Core and accessory genome of *Fusarium circinatum*
Advisors: BD Wingfield & ET Steenkamp

Angelica Marsberg
Genetics of the endophyte-host interaction
Advisors: B Slippers, S Naidoo & MJ Wingfield

Celia Martins
Characterising four cowpea (*Vigna unguiculata* (L.) Walp.) Mozambique landraces deposited in a seed bank for drought tolerance
Advisor: J Vorster

James Mehl
Factors affecting the distribution of selected species of the Botryosphaeriaceae
Advisors: MJ Wingfield, B Slippers & J Roux

Mandy Messal
Endophyte-host interactions
Advisors: B Slippers, M Kemler & S Naidoo

Ritesh Mewalal
Functional characterisation of Cell Wall-related Proteins of Unknown Function (CW-PUFs) in *Arabidopsis thaliana*
Advisors: AA Myburg, SD Mansfield & E Mizrachi

Jacqueline Meyer
Transcriptomics of the maize-GLS pathosystem
Advisors: DK Berger & SL Murray

Lorraine Mhoswa
Genome wide association study for *Leptocybe* resistance and associated chemotypes in *E. grandis*
Advisors: S Naidoo & AA Myburg

Alain Misse
Ceratocystis species and their insect associates in the Tsitsikamma National Forests, South Africa
Advisors: J Roux & MPA Coetzee

Osmond Mlonyeni
Population genetics of *Deladenus siricidicola*
Advisors: B Slippers, B Hurley, MJ Wingfield & BD Wingfield

Waheed Mahomed
Unraveling the *Phytophthora cinnamomi* triggered defence pathways of *Persea americana*
Advisors: N van den Berg & B Crampton

Valery Moloto
Bacterial diseases of onions
Advisors: TA Coutinho, T Goszczynska & L du Toit

Mmoledi Mphahlele
Genome-wide selection for growth and wood property traits in *Eucalyptus grandis*
Advisors: AA Myburg, F Isik & G Hodge

Gloria Mukwirimba
Fungal and bacterial seedborne pathogens of brassica species in Gauteng province, Waterberg district in Limpopo province and alternative seed treatment methods
Advisors: TAS Aveling & Q Kritzinger

Margot Muller
Bacterial canker of cherry trees
Advisors: TA Coutinho, Y Petersen & J Roux

Eston Mutitu
The biological control of *Thaumastocoris peregrinus* using *Cleruchoides noacke*
Advisors: B Slippers, J Garnas, BP Hurley & MJ Wingfield

Abubaker Muwonge
Evaluation of expression of the *Hrap* and *Pflp* genes in transgenic banana plants for resistance against *Xanthomonas campestris pv. musacearum*
Advisor: J Vorster

Jan Nagel
Causes and consequences of speciation within the *Neofusicoccum parvum/ribes* complex
Advisors: B Slippers & MJ Wingfield

Buyani Ndlovu
Functional characterisation of putative *RxLR* effector genes from *Phytophthora cinnamomi*
Advisor: N van den Berg

Nare Ngoepe
Genome imputation and genome-wide association of fibre cell wall biosynthesis *in Eucalyptus grandis*
Advisors: AA Myburg & CA Hefer

David Nsibo
Population genetics of *Cercospora zeina*
Advisors: DK Berger & I Barnes

Caryn Oates
A system's biology model of the interaction between *Eucalyptus* and the galling pest, *Leptocybe invasa*
Advisors: S Naidoo, AA Myburg, B Slippers & K Denby

Sarai Olivier
Ecological and evolutionary determinants of insect community on *Acacia mearnsii*
Advisors: J Garnas & BP Hurley

Edward Onkendi
High throughput functional analysis of *Pectobacterium*
Advisors: L Moleleki & IK Toth

John Alexander Osorio
Fungal diseases of mangroves and associated trees in South Africa
Advisors: J Roux, MJ Wingfield & W de Beer

Mmatshepho Phasha
Pathogenicity factors of *Fusarium* species
Advisors: ET Steenkamp, BD Wingfield & MPA Coetzee

Zelda Pieterse
Analysis of fungi associated with *Mesembryanthemaceae* from the succulent Karoo
Advisors: TAS Aveling & R Jacobs

Priyen Pillay
Transcriptome analysis of proteases induced upon Agro-infiltration and recombinant expression of genes in *Arabidopsis*
Advisor: J Vorster

Desre Pinard
The role of plastids and mitochondria in carbon allocation in the xylem of *Eucalyptus*
Advisors: E Mizrachi & AA Myburg

Alisa Postma
Genomics of *Sirex-Amylostereum-Deladenus*
Advisors: B Slippers, F Joubert & MJ Wingfield

David Read
Overcoming bias in Citrus tristeza virus (CTV) genotype detection and a population study of CTV within southern African Star Ruby grapefruit orchards
Advisor: G Pietersen

Danielle Roodt
Gene evolution of non-coniferous gymnosperms
Advisors: E Mizrachi & Y van de Peer

Quentin Santana
Genome evolution and characteristics of *Fusarium circinatum*
Advisors: MPA Coetzee, BD Wingfield, ET Steenkamp & MJ Wingfield

Mohammad Sayari
Pathogenicity factors of *Ceratocystis* species
Advisors: BD Wingfield & ET Steenkamp

Vou Shutt
Bacterial diseases of potatoes in Nigeria
Advisors: TA Coutinho & J van der Waals

Phathie Sibanda
Gene regulation in quorum sensing of *Pantoea ananatis*
Advisors: TA Coutinho, L Moleleki, D Shyntum & Y van de Peer

Melissa Simpson
Microsatellite analysis of *Ceratocystis* species
Advisors: BD Wingfield, MPA Coetzee & MJ Wingfield

Fred Ssekiwoko
The mechanism of resistance to *Xanthomonas vasicola pv. musacearum* explored in *Musa balbisiana*
Advisor: K Kunert

Michel Tchotet
Woodrot fungi on native African trees
Advisors: J Roux, MPA Coetzee & N Rajchenberg

Riaan Thompson
Fungal seedborne pathogens of pine
Advisors: TAS Aveling & J Roux

Ariska van der Nest
Host specificity and virulence of *Ceratocystis fimbriata* and *C. manginecans*
Advisors: I Barnes & MJ Wingfield

Johan van der Linde
Diseases of native tree *Euphorbia* species in Southern Africa
Advisors: J Roux, D Six and MJ Wingfield

Stefan van Wyk
Soybean nodule development and senescence: the role of cysteine proteases and inhibitors
Advisor: J Vorster

Erika Viljoen
Genetic diversity analysis of the Amaranthus genus using genomic tools
Advisors: DK Berger, D Odeny & J Rees

Ronel Viljoen
Characterization of *Candidatus* Liberobacter africanus subspecies from indigenous Rutaceae in South Africa
Advisor: G Pietersen

Erik Visser
Models of defence mechanisms in *Pinus* species against *Fusarium circinatum*
Advisors: S Naidoo, E Steenkamp, L Wegryzn & AA Myburg

Tania Weller-Stewart
Genomic and functional characterisation of motility in *Pantoea ananatis*
Advisors: TA Coutinho, P de Maayer & I Toth

Markus Wilken
Characterisation of the *Ceratocystis fimbriata* genome
Advisors: BD Wingfield, MJ Wingfield, ET Steenkamp & W de Beer

Lizahn Zwart
Characterising the temporo-spatial defense responses of *Eucalyptus grandis* to the fungal stem canker pathogen *Chrysoporthe austroafricanus*
Advisors: S Naidoo, AA Myburg, D Berger, A van der Merwe & L Moleleki

MSc Students

Juanita Avontuur
Characterisation of novel Bradyrhizobium species associated with indigenous legumes
Advisors: SN Venter & ET Steenkamp

Colan Balkwill
Genetic architecture and robustness of the circadian clock in a *Eucalyptus grandis x E. urophylla* backcross
Advisors: E Mizrachi & AA Myburg

Andrew Behrens
Total RNA sequencing and discovery of non-coding RNAs in *Eucalyptus* xylem
Advisors: E Mizrachi & AA Myburg

Kay Bophela
Enterobacter and *Xanthomonas* species associated with blight and die-back of *Eucalyptus*
Advisors: TA Coutinho & SN Venter

Caitlin Botha
The genetics of sexual reproduction in a Basidiomycete, *Amylostereum areolatum*
Advisors: B Slippers, MPA Coetzee & MA van der Nest

Kirsty Botha
Characterisation of the cannabinoid biosynthetic pathway in *Helichrysum umbraculigerum*
Advisors: BG Crampton & D Heyman

Michael Bufe
The early physiological response of avocado rootstocks to infection with *Phytophthora cinnamomi*
Advisors: N van den Berg & N Taylor

Samantha Bush
Risk of *Glycaspis brimblecombei* to South African plantations
Advisors: BP Hurley & B Slippers

Megan Calvert
Genome-wide dissection of secondary cell wall transcription factor expression in *Eucalyptus* hybrids
Advisors: AA Myburg & E Mizrachi

Daniela Arriagada Cares
The global diversity and introduction history of *Glycaspis brimblecombei* and its endosymbiont
Advisors: B Slippers & J Garnas

Vanessa Cronje
Pantoea ananatis and *P. allii* associated with onion seedlings
Advisors: TA Coutinho & N van den Berg

Herman de Bruin
Entomopathogens affecting tree pests in South Africa
Advisors: B Slippers & W de Beer

Katrien de Ridder
Maize diseases of small holder farmers in South Africa
Advisors: TAS Aveling & D Berger

Magdaleen du Plessis
Cysteine proteases activity and gene expression in soybean nodules during development and drought stress
Advisor: J Vorster

Angelique du Preez
Flagella glycosolation in *Pantoea ananatis*
Advisors: P de Maayer & TA Coutinho

Yves du Toit
The development of a comparative transcriptomic tool to interrogate common defence mechanisms in *Eucalyptus grandis* under various biotic challenges
Advisors: S Naidoo, N Christie & AA Myburg

Ludwig Eksteen
Host use and spatial pattern of attachment in the invasive European wood wasp, *Sirex noctilio*
Advisors: J Garnas & BP Hurley

Miranda Erasmus
Taxonomy and biology of the *Ophiostoma abietinum* complex
Advisors: W de Beer, MJ Wingfield & TA Duong

Simone Fouche
Molecular characterisation of an accessory chromosome of *Fusarium circinatum*
Advisors: ET Steenkamp, MPA Coetzee and BD Wingfield

Megan Harris
Detection of grapevine leafroll associated viruses in *Vitis* rootstocks
Advisor: G Pietersen

Barend Jansen van Vuuren
Population dynamics of *Phytophthora cinnamomi* in South African avocado orchards
Advisors: N van den Berg & I Barnes

Tshepang Khahlu
Regulation of photosynthesis and nitrogen fixation in soybean
Advisor: J Vorster

Nelisiwe Khumalo
Pathogenicity of *Phytophthora cinnamomi* on avocado in South Africa
Advisors: N van den Berg & TA Coutinho

Ncobile Kunene
Mating type gene analysis of *C. zeina* populations in South Africa
Advisors: DK Berger & S Phillips

Rofhiwa Nesamari
Diseases of South African Encephalartos species
Advisors: J Roux & TA Coutinho

Matt Laubscher
The identification of transcriptional networks underlying secondary cell wall formation in *Eucalyptus* xylem vessels and fibres
Advisors: S Hussey, E Mizrachi & AA Myburg

Teboho Letsoalo
Ophiostomatoid fungi and their insect associates in South Africa and Uruguay – Taxonomy, diversity and insect associates
Advisors: J Roux & MJ Wingfield

Johan Liversage
Functional characterisation of the *Cercospora zeina crpl* gene in pathogenesis
Advisors: BG Crampton & DK Berger

Jackie Lubbe
Molecular and biological characterisation of three Citrus tristeza virus candidate cross-protection sources
Advisor: G Pietersen

Angel Maduke
Botryosphaeriaceae associated with native and introduced Myrtaceae in Southern Africa
Advisors: J Roux & D Pavlic

Palesa Madupe
Comparative genomics of *Xanthomonas vasicola* from different hosts
Advisors: TA Coutinho & SN Venter

Ntwanano Maluleke
The impact of soft rot pathogens on crop production in South Africa
Advisor: L Moleleki

Tintswalo Maluleke
Transcriptome analysis and protease identification in the gut of *Cosmopolites sordidus*
Advisor: J Vorster

Claire Martin
Elucidation of medicinally active dicaffeoylquinic acid derivatives from *Helichrysum populifolium*
Advisors: BG Crampton & D Heyman

Lerato Maubane
Pine needle fungal endophytes including species of *Lophodermium*
Advisors: M Gryzenhout, B Slippers & MJ Wingfield

Lungi Mavuso
Studying the effect of salt stress on avocado tree health
Advisors: N van den Berg & N Taylor

Brittany Mitchell
Studying the defence pathways in a tolerant and susceptible avocado infected *with Phytophthora cinnamomi*
Advisors: N van den Berg & B Reeksting

Molly Molefo
Functional characterisation of the putative pathogenicity gene*, czk3* in *Cercospora zeina*
Advisors: BG Crampton & DK Berger

Gabolwelwe Mosina
Towards understanding induced resistance mechanisms of potato plants
Advisor: L Moleleki

Tshepiso Motlomelo
Cyclic-di-GMP, a small signalling molecule aiding communication SRE
Advisor: L Moleleki

Yolanda Musasira
Population studies on *Armilaria s*pecies in South Africa
Advisors: MPA Coetzee& MJ Wingfield.

Mashudu Nxumalo
Diversity of nitrogen symbionts of *Lebeckia* species
Advisors: SN Venter & ET Steenkamp

Liezl Potgieter
Armillaria polygalacturonases
Advisors: MPA Coetzee and BD Wingfield

Rudi Pretorius
Phenotypic analysis of AHL defective Pcb mutants
Advisors: L Moleleki & J Theron

Stefan Priem
Root knot nematodes interaction with Pcb – the role of biofilms
Advisors: L Moleleki & TA Coutinho

Mohd Redzuan Abdul Rauf
Diseases of forestry importance to Malaysia
Advisors: MJ Wingfield, I Barnes & J Roux

Kavani Sanasi
Fungal associates of pine bark beetles in Guatemala
Advisors: W de Beer, MJ Wingfield & TA Duong

Mohamed Seedat
Identification of Crinkler (CRN) effector genes in *Phytophthora cinnamomi* during avocado root infection
Advisors: N van den Berg & S Naidoo

Karabo Sereme
Description of new *Burkholderia* species
Advisors: SN Venter, ET Steenkamp & E Venter

Gina Shin
Population diversity of *Pantoea ananatis*
Advisors: SN Venter & TA Coutinho

Vimbai Siziba
Population genetics of DNB pathogen, *Dothiostroma pini*
Advisors: I Barnes & MJ Wingfield

Rynhard Smit
Identification of molecular markers to assess *Moringa oleifera*
Advisor: J Vorster

Kirsti Snyders
Detection and isolation of homogeneous genotypes of Citrus tristeza virus for use in virus control through cross protection
Advisor: G. Pietersen

Nardus Strydom
Functional genomics of toxin biosynthesis in *C. zeina*
Advisors: DK Berger & BG Crampton

Riaan Swanepoel
De novo assembly and annotation of a gene catalogue from *Welwitschia mirabilis*
Advisors: E Mizrachi & F Joubert

Collins Tanui
Gene expression profiling of *Pectobacterium* in different environments
Advisor: L Moleleki

Junior Tii-Kuzu
Population genomics and molecular breeding in *Eucalyptus*
Advisor: AA Myburg

Conrad Trollip
Pathogenesis of *Ceratocystis eucalypticola*
Advisors: BD Wingfield, MA van der Nest, I Barnes, MJ Wingfield

Stephanie van Wyk
Molecular characterisation of the growth rate determining quantitative trait locus in *Fusarium circinatum*
Advisors: ET Steenkamp, NA van der Merwe, L de Vos & BD Wingfield

Jennifer Wayland
Development of a diagnostic system for viruses of grapevines based on polyspecific PCR
Advisor: G Pietersen

Martin Wierzbicki
Systems genetics of xylan side chain modifications in *Eucalyptus*
Advisors: AA Myburg & E Mizrachi

Andi Wilson
Mating system in *Huntiella* species
Advisors: BD Wingfield, MA van der Nest, PM Wilken, MJ Wingfield

4TH YEAR AND HONOURS STUDENTS

Afrah Khairalla (2013)
Amy Visser (2013)
Erika Bruck (2013)
J Potgieter (2013)
Andi Wilson (2013)
Janus van As (2013)
Juanita Avontuur (2013)
Kavani Sanasi (2013)
Kirsten Kenchenten (2013)
Nompumelelo Msiza (2013)
Kristy Botha (2013)
Matt Laubscher (2013)
Yolanda Musasira (2013)
Thandekile Mamni (2013)
Tshepang Khahlu (2013)
Leonora Haasbroek (2014)
Martin Wierzbicki (2014)
Miranda Erasmus (2014)
Lizel Potgieter (2014)
Stefan Priem (2014)
Conrad Trollip (2014)
Andrew Behrens (2014)
Ashleigh Geldenhuys (2014)
Benedicta Swalarsk-Parry (2014)
Boitumelo Masilo (2014)
Brittany Mitchell (2014)
Gibson Gondo (2014)
Inge Pietersen (2014)
Ore Odunsi (2014)
Karin van der Westhuizen (2014)
Juanita Hanneman (2015)
Johnathan Bredenkamp (2015)
Donovin Coles (2015)
Esna du Plessis (2015)
Hanlica Erasmus (2015)
Pfano Mbedzi (2015)
Pitsi Mokou (2015)
Robyn Kahn (2015)
Stephan Engelbrecht (2015)
Nadine Koen (2015)
Wilma Nel (2015)
Xongi Khosa (2015)
Katrien Brown (2015)
Malebo Makunyane (2015)
Marike Louw (2015)
Monique Otto (2015)
Edohan Clasen (2015)
Gabriella Barnard (2015)
Catherine Tatum (2015)
Catherine Wickham (2015)
Candice Herd (2015)

STUDENT ASSISTANTS

Andrew Ntuli (2013)
Antonie Kloppers (2013)
Biotumelo Ntlaleng (2013)
Mpho Sekgejane (2013, 2014)
Catherine Wickham (2014)
Donovin William Coles (2014)
Georgia Leiseganad (2014)
Jonathan Lloyd Seaman (2014)
Sina Malebana (2014)
Loandi Richter (2015)
Modjaji Makwela (2015)
Mzuvumile Mbane (2015)
Nomakula Yvonne Zim (2015)
Tanya Welgemoed (2015)
Walter Bronkhorst (2015)

FACULTY MENTORSHIP STUDENTS

Anri Pieterse (2013)
Elelwani Ramulifho (2013)
Junior Tii-Kuzu (2013)
Martin Wierzbicki (2013)
Nardus Strydom (2013)
Robyn-Leigh Smith (2014)
Alandie Niewoudt (2014)
Gert Pietersen (2014)

RECENT GRADUATES

PhD

Nanette Christie (2013)
Transcriptional regulation underlying the quantitative genetic response of maize to grey leaf spot disease
Advisors: DK Berger & AA Myburg

Tuan Duong (2013)
Molecular characterisation of *Leptographium serpens* and related species
Advisors: MJ Wingfield, BD Wingfield & W de Beer

Michael Mbenoun (2013)
Diveristy, ecology and taxonomy of tree infecting *Ceratocystis* species in Africa
Advisors: J Roux, MJ Wingfield, BD Wingfield & BAD Begoude

Matšepo Taole (2013)
Phylogenetic reassessment and population biology of the *Eucalyptus* pathogen *Teratosphaeria epicoccoides* isolated from diseased *Eucalyptus* leaves
Advisors: BD Wingfield, T Burgess & MJ Wingfield

Marelize van Wyk (2013)
Phylogenetic relationships and taxonomy of species in *Ceratocystis sensu lato*
Advisors: MJ Wingfield & BD Wingfield

Tendai Musvuugwa (2013)
Biodiversity and ecology of Ophiostomatoid fungi associated with native trees in the Cape Floristic Region
Advisors: MJ Wingfield & W de Beer

Nicky Creux (2013)
In silico and functional characterisation of the *cellulose synthase 1* gene promoter of *Eucalyptus* trees
Advisors: AA Myburg & C Maritz-Olivier

Eshchar Mizrachi (2013)
Functional genomics and systems genetics of cellulose biosynthesis of *Eucalyptus*
Advisors: AA Myburg, S Mansfield & DK Berger

Steven Hussey (2013)
Functional genomics of NAC transcription factor SND2 regulating secondary cell wall biosynthesis in *Arabidopsis* and *Eucalyptus*
Advisors: AA Myburg & DK Berger

Rene Sutherland (2013)
The effect of cold stress on resistance in Cavendish bananas to Fusarium wilt
Advisors: N van den Berg, A Viljoen, R Chikwamba & AA Myburg

Rodrigo Ahumada (2013)
Diseases of *Pinus radiata* in Chile
Advisors: MJ Wingfield & B Slippers

Kershney Naidoo (2014)
Mitochondrial genomes and concerted evolution in *Ceratocystis*
Advisors: BD Wingfield, ET Steenkamp & MJ Wingfield

Divine Shyntum (2014)
Characterising the Type VI secretion system in *Pantoea ananatis*
Advisors: TA Coutinho, SN Venter & I Toth

Bertha-Lucia de Castro (2014)
Stem and root diseases of coffee in Colombia

Fahimeh Jami (2014)
Taxonomy and ecology of the Botryosphaeriaceae associated with *Acacia karoo* in South Africa
Advisors: M Gryzenhout, B Slippers & MJ Wingfield

Dawit Degefu (2014)
Biology and biological control of *Coryphodema tristis*
Advisors: B Slippers, B Hurley, J Garnas & MJ Wingfield

Gudrun Dittrich-Schröder (2014)
Molecular ecology of *Leptocybe nvasa* (Hymenopetra: Eulophidae) and its biological control agent in South Africa
Advisors: B Slippers, MJ Wingfield & BP Hurley

Marc Bouwer (2014)
Chemical communication of key forest pests in South Africa
Advisors: E Rohwer, B Slippers & MJ Wingfield

Bianca Reeksting (2015)
Elucidating the early response of *Persea americana* to *Phytophthora cinnamomi* and flooding
Advisors: N van den Berg & N Taylor

MSc

Linda Ndove (2013)
Botryosphaeriaceae associated with Podocarpaceae in South Africa
Advisors: B Slippers, MJ Wingfield & E de Meyer

Amy Wooding (2013)
Sex determination and symbiont transmission in the *Sirex-Amylostereum* mutualism
Advisors: B Slippers, J Garnas, B Hurley, J Greeff & MJ Wingfield

Lindsay Kriel (2013)
Development of tissue culture, *in vitro* micropropagation and transformation techniques and the characterisation of thaumatin, a potential defence-related gene in *Persea americana* Mill.
Advisor: N van den Berg

Edward Onkendi *cum laude* (2013)
Root knot nematodes
Advisor: L Moleleki

Aobakwe Mongae (2013)
Potato nematodes
Advisor: L Moleleki

Gugu Kubheka (2013)
Fluorescent protein tagging system for *Pectobacterium* spp.
Advisors: L Moleleki & TA Coutinho

Lenny Mashavha (2013)
Genetic diversity of *Pectobacterium* in South Africa
Advisors: L Moleleki & TA Coutinho

Tracy Godlonton [neè Hall] (2013)
Mating locus structure in *Ceratocystis moniliformis* and a gene duplication in *Ceratocystis* species
Advisors: BD Wingfield, MJ Wingfield & M Wilkin

Darryl Herron (2013)
Characterisation of *Fusarium* species from *Pinus* and *Eucalyptus* nurseries in Colombia and South Africa
Advisors: ET Steenkamp, BD Wingfield, MJ Wingfield & WFO Marasas

Mmatshepho Phasha (2013)
Intron architecture in *Fusarium*
Advisors: ET Steenkamp, BD Wingfield & MPA Coetzee

Ronel Viljoen (2013)
"*Candidatus* Liberibacter" in four indigenous Rutaceae species from South Africa
Advisors: G Pietersen & ET Steenkamp

Phathie Sibanda *cum laude* (2013)
Quorum sensing systems in *Pantoea ananatis*
Advisors: TA Coutinho & J Theron

Jonathan Botha (2013)
Qualitative reporter gene and targeted yeast one-hybrid analysis of the *Eucalyptus grandis SND2* promoter region
Advisors: AA Myburg, C Maritz-Olivier & E Mizrachi

Desre Pinard *cum laude* (2013)
Genome-wide analysis of carbohydrate active enzyme diversity and expression in *Eucalyptus grandis*
Advisors: AA Myburg, E Mizrachi & F Joubert

Ida van Jaarsveld *cum laude* (2013)
Basal promoter landscape in *Eucalyptus grandis:* annotation of distal transcription start sites and core promoter usage
Advisors: AA Myburg, F Joubert & E Mizrachi

Jane Bredenkamp (2014)
Characterisaton of tolerance to bacterial wilt in the model plant *Arabidopsis*
Advisors: DK Berger & S Naidoo

Caryn Oates *cum laude* (2014)
Investigation into the early defence response of a resistant *Eucalyptus grandis* clone to *Leptocybe invasa*
Advisors: S Naidoo, AA Myburg & B Slippers

Febe Wilken *cum laude* (2014)
Transcript profiling in roots of *Eucalyptus smithii* infected with the oomycete pathogen *Phytophthora cinnamomi*
Advisors: S Naidoo, N van den Berg & AA Myburg

Arista Fourie (2014)
Distinguishing between cryptic species in the *Ceratocystis fimbriata sensu lato* species complex
Advisors: I Barnes, BD Wingfield & MJ Wingfield

Tondani Kone (2014)
The characterisation and evolution of pheromone receptors in the *Sordariomycetes*
Advisors: ET Steenkamp, BD Wingfield, NA van der Merwe & G Fourie

Mkhululi Maphosa (2014)
Identification of unique genes in the genome of *Fusarium circinatum* and the development of a robust diagnostic technique using these sequences
Advisors: BD Wingfield & ET Steenkamp

Phia van Coller (2014)
Characterising mutagenesis in *Fusarium circinatum*
Advisors: ET Steenkamp, BD Wingfield & MPA Coetzee

Jon M Ambler (2014)
Genome characterisation, with special reference to gene silencing mechanisms, of *Armillaria fuscipes*
Advisors: MPA Coetzee, ET Steenkamp & F Joubert.

Silvia Natal David Mausse-Sitoe (2014)
Identity and impact of *Eucalyptus* diseases in Mozambique
Advisors: J Roux & MJ Wfingfield

Nicole Rudolph *cum laude* (2014)
Efficacy of selected rhizobacterial isolates for biocontrol of *Rhizoctonia solani* and growth promotion of maize in South Africa
Advisors: TAS Aveling & N Labuschagne

Pooja Singh *cum laude* (2014)
Transcriptome-wide analysis of predicted proteome variation segregating in a *Eucalyptus* hybrid family
Advisors: AA Myburg & E Mizrachi

Janneke Aylward University of Stellenbosch **(2014)**
Diversity and dispersal of the ophiostomatoid fungus, *Knowdaviesia proteae*, within *Protea repens* infructescences
Advisors: F Roets, LL Dreyer, ET Steenkamp & MJ Wingfield

Ariska van der Nest (2014)
Comparative study on *Phoma sorghina* associated with indigenous trees and commercially produced food crops
Advisors: GJ Marais & ET Steenkamp

Brigitte Lombard (2014)
Characterisation of three putative effector genes from the maize foliar pathogen *Cercospora zeina*
Advisors: BG Crampton & DK Berger

Miekie Haasbroek (2014)
Characterisation of *Exserohilum turcicum* isolates within South African maize production areas
Advisors: BG Crampton & I Barnes

Nare Ngoepe (2014)
Genotyping-by-sequencing of sweet stem and grain sorghum for genetic mapping
Advisors: BG Crampton, J Rees & D Odeny

Sonia Naidoo (2014)
Genetic studies of yield and fresh colour in sweet potatoes
Advisors: BG Crampton, D Odeny & J Vorster

Anandi Reitmann *cum laude* (2014)
Identification of pathogenicity-related genes in *Phytophthora cinnamomi*
Advisors: N van den Berg & DK Berger

Elrea Appelgryn (2014)
Investigation of the *Phytophthora cinnamomi-Persea americana* interaction with a fluorescently-tagged strain of *P. cinnamomi*
Advisors: N van den Berg, B Crampton & TA Coutinho

Sitha Ramsuchit (2014)
Pathogencity of mating types of *Phytophthora cinnamomi* in *Eucalyptus* and avocado
Advisors: N van den Berg & S Naidoo

Zander Human (2014)
Actinomycete bacteria associated with forest insects
Advisors: SN Venter, MJ Wingfield, ZW de Beer & B Slippers

Thomas Schmidt (2015)
Bolistic transformation in maize leaves
Advisors: DK Berger & BG Crampton

Monique Heystek (2015)
Promoter analysis of three defence gene family members from maize in response to *Cercospora zeina*
Advisors: DK Berger & BG Crampton

Degracious Kgoale (2015)
Gene expression study of candidate *Arabidopsis* defence genes in response to the bacterial wilt pathogen
Advisors: DK Berger & S Naidoo

Mischa Muller (2015)
Molecular diversity of the maize pathogen *Cercospora zeina* in South Africa
Advisors: DK Berger, BG Crampton & I Barnes

Erik Visser *cum laude* (2015)
Pinus patula transcriptome assembly
Advisors: S Naidoo, ET Steenkamp & AA Myburg

Rynier Lourens (2015)
Molecular characterisation of the *Eucalyptus NPR1* gene ortholog
Advisors: S Naidoo & AA Myburg

Danielle Roodt (2015)
The mating genetics and core genome of *Ceratocystis albifundus*
Advisors: BD Wingfield, MJ Wingfield & PM Wilken

Francois Boshoff (2015)
Bradyrhizobium species associated with native and non-native *Acacia* species
Advisors: ET Steenkamp & SN Venter

Olga Makhari (2015)
Population biology of *Fusarium circinatum* Nirenberg et O'Donnell associated with South African *Pinus radiata* D. Don plantation trees
Advisors: ET Steenkamp, TA Coutinho & MJ Wingfield

Katie Termer (2015)
Biotic and abiotic determinants of resource quality for larvae of *Sirex noctilio*
Advisor: J Garnas

Sarah Stanton (2015)
Phytochemical and morphological comparison between *Pachystigma* species
Advisors: M Meyer & TA Coutinho

Susan de Raan *cum laude* (2015)
Management of soft rot and black leg of potatoes in South Africa
Advisors: J van der Waals & TA Coutinho

Edgar Mangwende (2015)
Seedborne fungi of herbs cultivated in South Africa and evaluation of non-chemical seed treatments to control *Alternaria* sp. on coriander
Advisors: TAS Aveling & Q Kritzinger

PRESTIGIOUS NRF BURSARY HOLDERS

Martin Wierzbicki (2014)

NRF SCARCE SKILLS/INNOVATION SCHOLARSHIPS

Desre Pinard, 2014-2016
Colan Balkwill, 2014-2015
Lizahn Zwart, 2015-2016
Caryn Oates, 2014-2016
Erik Visser, 2013-2014
Ronishree Mangwanda, 2012-2014
Andrew Behrens, 2015-2016
Martin Wierzbicki, 2015-2016
Martin Laubscher, 2014-2015
Jonathan Botha, 2014-2016
Danielle Roodt, 2013-2014
Molly Molefo (2013-2014)
Miekie Haasbroek (2012-2013)
Brigitte Lombard (2013-2014)
Kirsty Botha (2014-2015)
Robert Backer (2014)
Bianca Reeksting (2013-2014)
Waheed Mahomed (2012-2014)
Nelisiwe Khumalo (2013-2014)
Mohamed Seedat (2014)
Elrea Appelgryn (2013-2014)
Anandi Reitmann (2012-2014)
Vanessa Cronje (2012-2014)
Mohammad Sayari (2014-2016)
Simone Fouche (2013-2014)
Stephanie van Wyk (2013-2014)

MANDELA-RHODES SCHOLARSHIPS

Osmond Mlonyeni
Mmatshepho Phasha

OTHER SCHOLARSHIPS

Sonia Naidoo (Canon Collins Scholarship)

MANAGEMENT

MANAGEMENT COMMITTEE

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Prof. TA Coutinho
Prof. K Kunert
Prof. AA Myburg
Extraordinary Prof. G Pietersen
Prof. J Roux
Prof. B Slippers
Prof. MJ Wingfield (Chairman)

Assoc. Prof. TAS Aveling
Assoc. Prof. L Moleleki
Assoc. Prof. ET Steenkamp
Assoc. Prof. N van den Berg

Dr. I Barnes
Dr. M Coetzee
Dr. B Crampton
Dr. ZW de Beer
Dr. J Garnas
Dr. B Hurley
Dr. E Mizrachi
Dr. K Naidoo
Dr. S Naidoo
Dr. A van der Merwe
Dr. J Vorster
Ms. A Wooding (Postgraduate student representative 2013)
Mr. D Herron (Postgraduate student representative 2015)
Dr. L Shuey (Postdoctoral representative 2015)

ADVISORY COMMITTEE

Prof. A Ströh, Previous Dean of the Faculty of Natural and Agricultural Sciences (until mid-2014)
Prof. J Lubuma (Chairman), Dean of the Faculty of Natural and Agricultural Sciences
Prof. P Bloomer, Head of the Department of Genetics
Prof. SN Venter, Head of the Department of Microbiology & Plant Pathology
Prof. Dittrich-Schubert, Acting Head of the Department of Biochemistry
Prof. D Berger, Acting Head of the Department of Plant Science
Prof. C Allandale, Head of the Department of Plant Production
Prof. C Chimimba, Head of the Department of Zoology & Entomology
Prof. P Chirwa, SAFCOL Forest Chair
Prof. CL Machethe, Postgraduate School of Agriculture and Rural Development
Prof. D Cowan, GRI
Prof. BD Wingfield, Deputy Dean of NAS
Prof. MJ Wingfield, Director of FABI

SOME SOCIAL HIGHLIGHTS IN FABI

Annual SPOOF meeting 2013*

**Society for the Publication Of Outrageous Findings*

THEME: FRIDAY THE 13TH

Wilhelm de Beer and Mike Wingfield

Teresa Coutinho, Emma Steenkamp and Albé van der Merwe

Jolanda Roux

Prof. George Hudler from Cornell University, USA

Luke Jimu, Felix Fru and Alain Misse

Albé van der Merwe, Prof. Lori Eckhart,
Mrs. Hudler and Prof. George Hudler

Annual SPOOF* meeting 2014

*Society for the Publication Of Outrageous Findings

THEME: THE CIRCUS CARNIVAL

Caitlin Botha, Ariska van der Nest and Amy Wooding

Lucas Shuttleworth

Jolanda Roux and FeiFei Liu

Stephen Taerum, Brenda Wingfield and Mike Wingfield

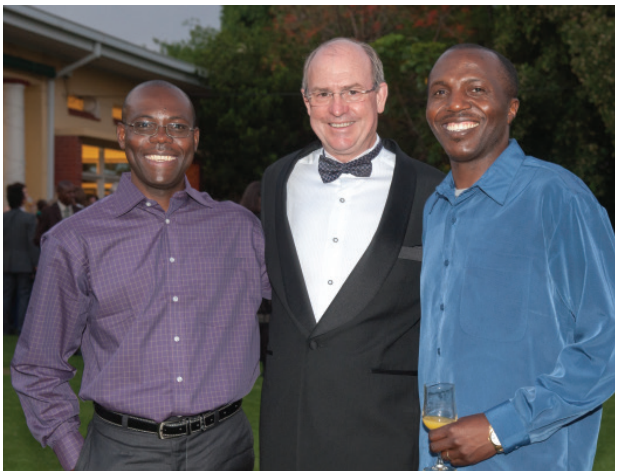
Zander Human and Casper Crous

Conrad Trollip, Andi Wilson, Deon de Jager and Brittany Mitchell.

YEAR-END FUNCTION 2013

Jeanne Korsman, Jane Bredenkamp
and Johan Liversage

Tuan Duong, Juanita Engelbrecht,
Bradley Paterson and Brittany Mitchell



Michael Mbenoun, Mike Wingfield and Felix Fru

Mike Wingfield and Markus Wilken

Brenda Wingfield and Mike Edwards

Dr. Andre Drenth, University of Queensland, Australia

YEAR-END FUNCTION 2014

Mr. Pillay, Ms. Jaywanti Pillay and Mike Wingfield

Noëlani van den Berg, Anton van den Berg,
Chrisné Myburg and Zander Myburg

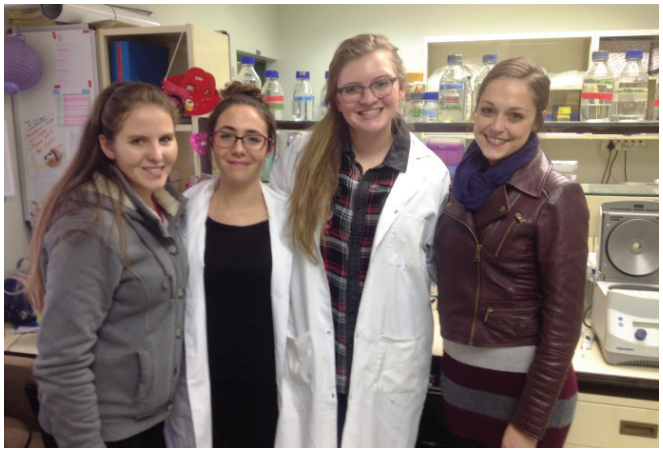
Mike Wingfield, Prof. Cheryl de le Rey,
Mr. Elridge Johnson and Brenda Wingfield

Andrew Crampton, Bridget Crampton,
Felix Middleton and Dr. Rikus Kloppers

Gibson Gondo, Ashleigh Geldenhuys,
Miranda Erasmus and Benedicta Swalarsk-Parry

Mike Wingfield and Ritesh Mewalal

COMMUNITY INITIATIVES



Andi Wilson, Nadia Santosuosso,
Lenschen Greyling and Danielle Roodt

COMMUNITY PROJECTS 2013 AND 2014

FABI prides itself not only on research excellence but also in helping less fortunate members of the community. A number of community projects are initiated annually under the enthusiastic guidance of Prof. Noëlani van den Berg.

The annual blanket drive in FABI has become a wonderful tradition and during the months creeping up to winter FABIans collected more than 150 blankets in 2013 and 180 blankets in 2014. These blankets were then handed over to TUKS FM who distributed them amongst the needy communities as part of their annual winter charity drive.

FABIans collected more than 150 blankets
that were donated to people in need.

In 2015 FABI decided to make a contribution to some aspect of education, which remains the primary objective of the Institute. FABI partnered with the NEA Foundation to donate 80 fully equipped school bags to learners from underprivileged communities in Pretoria West. A total of R18,000 was raised by FABI staff and students with the Hans Merensky Foundation, a research partner of FABI, donating a generous R10,000 to this total.

FABIans packed schoolbags filled
with stationery for Grade 1 learners.

Bambino Creche's learners were
recipients of FABI's school bags.

FABIans Felix Fru, Prof. Noëlani van den Berg and Redzuan Rauf
with learners from the Thando West Fort Community Creche.

The bags contained stationery and all the material necessary to allow the Grade One learners to start their school careers well equipped. The team also took along some sweets, crisps, cold drinks and cupcakes for the kids to enjoy the day before schools opened in the Gauteng province.

Felix Fru, Prof. Noëlani van den Berg and Redzuan Rauf with learners from the Thando West Fort Community Creche.

The Sunrise Community Creche in Melusi, Pretoria North were given school bags. Seen at the handover are Mashudu Nxumalo, Pricipal Francina Mashita, Ashok Prabhu and Ilkadim Kiper.

FABI also hosts visits every year from nearby located high schools. The Grade 11 Life Sciences student group from the Afrikaanse Höer Seunskool (Afrikaans Boys' High School – "Affies") and Grade 12 Life Sciences group from St Mary's Diocesan School for Girls were exposed to research being conducted at the Institute.

The students from St Mary's DSG were addressed by female academics. In 2015 Prof. Brenda Wingfield and Dr. Kershney Naidoo addressed the girls on the role and challenges faced by female academics as well as their vision for the future.

These visits to FABI give students an insight into the work being done at the University and gain a practical insight into research being conducted.

In an effort to better prepare their students for the important decision of choosing subjects for their final three years of school, Woodhill College in Pretoria requires Grade 9 pupils to partake in a work shadowing experience.

Two learners from this school, with an interest in genetics, visited FABI for some hands-on experience in the lab. They had a tour of the FABI facilities, did their own PCR, gel electrophoresis and sequencing analyses. In the process their many questions related to scientific research were answered.

We sincerely hope that these student visits have inspired them to consider a career in science as FABI is driven to motivate the next generation of scientists

St. Mary's DSG High school visit to FABI.

NOTES

NOTES

SPONSORS OF RESEARCH

Many of these commercial companies or organisations fund more than one programme in FABI:

ACIAR (Australia)
Amathole Forestry
BASF
BAYER
Belgium Embassy
China/South African Governments Bilateral Agreement
Chinese Academy of Forestry
CIRAD
Citrus Growers Association
Citrus Research International
CGIAR Generation Challenge Programme
CNRS/South African Government
CSIR
DFG (Deutsche Forschungs-Gemeinschaft: German Research Foundation)
Department of Agriculture, Forestry and Fisheries (DAFF)
Department of Trade and Industry through THRIP initiative
Department of Science and Technology through the Innovation Fund and CTHB
Department of Science and Technology through the NRF
Department of Science and Technology
Du Roi QMS
EARO, Ethiopia
European Union 6th Framework Agreement
EU FP7 TESTA project
Forestry South Africa
Hans Merensky Holdings
Hans Merensky Foundation
International Institute of Tropical Agriculture (IITA)
Italian/South African Governments Bilateral Agreement
GRI, University of Pretoria
Japanese/South African Governments Bilateral Agreement
Loskop Irrigation Board
Maize Trust
Mellon Foundation
Ministry of Education, China
Ministry of Finance, China
Ministry of Science and Technology, China
Mondi
Mountain to Ocean (MTO) Forestry
National Natural Science Foundation, China
National Research Foundation (NRF)
NCT
Norway/South Africa Governments Bilateral Agreement
Oppenheimer Foundation
PANNAR Seed Pty (Ltd)
PG Bison
Protein Research Foundation
Rockefeller Foundation
SABI
SAFCOL/Komatiland Forestry
Sappi
SIDA/South African Governments Bilateral Agreement
South Africa/Argentina Governments Bilateral Agreement
Syngenta South Africa
Tanzanian Government
Technology Innovation Agency
Thuthuka
Tuscan Namibia/DAAD (Germany)
TWK
UP Research Development Fund
Water Research Commission
Winetech
Wheat Cereal Trust
York Timbers

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