The Centre for Crop and Disease Management (CCDM) is co-supported by Curtin University and the Grains Research and Development Corporation (GRDC) and focuses on providing solutions to Australian farmers to combat major pathogens of wheat, barley, canola and pulses.

Established in 2014, the CCDM was this year recognised for its contribution to industry, and national research excellence, with a funding extension from the GRDC through until mid-2022.

The extension of funding will bring the total co-investment in CCDM from all parties to approximately $140 million over 8 years; enabling the centre to continue its efforts in reducing the economic impact of diseases and improved management of crops by Australian growers across three main areas of outputs:

- **Fungicide resistance** – by developing tools and strategies for industry to use to prevent and minimise its occurrence and impact.
- **Molecular genetics** – by discovering and providing breeders with genetic tools to breed cereal, oilseed and pulse varieties with improved disease resistance.
- **Farming systems** – by developing adoptable and profitable Integrated Disease Management (IDM) strategies for managing the evolution of resistance to fungicides and disease management.

Foliar fungal pathogens remain a major threat to crop production across Australia. CCDM researchers estimate that under current control systems, production losses are valued at between $920 million to $1 billion per annum – an $80 million increase since 2010.

To combat this, CCDM has nine research programs and one extension and outreach program, each delivering outcomes for industry.

The CCDM sits within Curtin’s School of Molecular and Life Sciences and builds on the University’s previous work through the Australian Centre for Necrotrophic Fungal Pathogens (ACNFP).

Since its inception, CCDM has grown from 20 to 60+ research and professional staff. It continues to build capacity in the agriculture research community with a growing number of postgraduate students undertaking Honours, Masters and PhD projects, some of whom you will have the chance to meet in this report.
COLLABORATION AND COMMUNICATION

Through field and laboratory-based research, as well as the development of effective farm management strategies, CCDM is actively working with industry and collaborators to reduce the impact of crop disease.

An essential part of this is constant engagement with the people we work with, and those we aim to help. Across 2017, CCDM researchers and representatives travelled Australia meeting with growers, agronomists, breeders, industry partners and government to talk about our research and the difference outcomes make through the value chain from breeders to growers to consumers.

OUR EFFORTS, OUR IMPACT

In 2017, CCDM engaged an independent consultant to talk with industry about the work we’re doing and the impact we’re having. Feedback to our ‘Most Significant Change’ analysis has been positive and we look forward to building further on this in years to come.

“Their people are systems thinkers” – “It’s basically the approach and the modelling of integrated systems thinking - their people (CCDM staff) are systems thinkers, which is driving this very important work. They’re doing not only pure research but applied systems research which is important because it’s not just about how much you spray, and what you spray, but they’re looking at other factors i.e. how much stubble contributes to disease risk. The group have got a very important role to play and are doing a good job in terms of understanding why we are, or need to do different things, and why and how we should be making decisions.” – Agronomist (#3)

“CCDM information is spot on” – “CCDM have arrived with perfect timing [given the amount of fungicide use and the risk of resistance] so they’re looking at how we manage things in the future and assessing resistance levels. The most significant change from CCDM at this stage is the information that they send out. The information flow is targeted well, it’s short and sharp and I think it’s having an impact compared to the information we had before. I think the best is yet to come from CCDM. Though they do work on a national scale, they are WA based, which means we get locally relevant information. CCDM are world-class, fantastic and are hitting their straps.” – Chemical Industry Representative (#1)

“Lots of good data” – “It’s the knowledge and understanding about resistance within, and between species, variety resistance and what to do about it. So, having that knowledge was part of the tipping point. It reinforced what we knew, and the lights came on. Basically it [knowledge of resistance issues] went from amber light to a big red light, a flashing red light, that said “whoa, slowdown!” – Agronomist # 6

RIDERS ON THE STORM OF RESISTANCE

Lars Kamphuis and Fran Lopez Ruiz

CCDM and the Australian Herbicide Resistance Initiative (AHRI) once again teamed up to deliver the third national Crop Protection Forum.

The event, targeting agronomists, was held in Dalby, Queensland in December with the aim of exploring the implications and solutions for chemical resistance in northern cropping systems.

More than 100 people attended with CCDM’s Dr Fran Lopez Ruiz and Dr Lars Kamphuis amongst a range of presenters gathered from across Australia.
As we look back on the year that was, it becomes increasingly clear that the CCDM is a force to be reckoned with in agricultural research, on so many fronts. As Co-Directors charged with the task of leading this team, we couldn’t be prouder.

Certainly, the announcement of a further 3 years of funding through to 2022 by the GRDC was a massive boost to the work we’re doing. With extended investment, our team will continue to surge ahead in its core business of reducing the economic impact of crop disease for Australian growers, while also growing our research capability to enable us to deploy new techniques and innovations to deliver research outcomes.

Collaboration continues to be a focus for us as industry and government entrusts the CCDM with leading and partnering key projects across the grains and food spectrum.

Innovative approaches to the work we do have seen a range of important research outcomes across all of our research themes and we know you will enjoy reading more about these through this report. Through field trials, lab-based research, industry engagement and the development of tools and strategies to improve farm management, CCDM’s work continues to influence decision-making by agronomists and most importantly growers, in the paddock.

Across the year we’ve identified new cases of fungicide resistance, expanded the reach of fungicide ‘baiting trials’, used high throughput technology to make better, faster diagnoses of the prevalence and impact of diseases, collaborated on key research projects, worked to establish a collection system for infected samples and helped identify and test new chemistry of fungicide compounds for use on Australian farms.

Our teams have developed new Australian genomic resources in the fight against yellow spot disease, as well as uncovered new evidence of additional yellow spot effectors in Australia, allowing us to develop even higher levels of resistance to this pathogen. Our researchers have also used ancient wheat lines to investigate genes responsible for septoria nodorum blotch (SNB) in wheat and are working to further enhance SNB resistance.

Our barley powdery mildew research continues to identify exotic resistance genes aimed at providing better solutions for Australian breeders and growers. Researchers have also uncovered new sources of resistance to net form net blotch (NFNB) in barley and are working to develop this research further with the aim of also providing effective information to breeders.

Crop diseases in canola and pulses also continue to be a focus of the CCDM. Researchers have developed effective phenotyping methods and identified genetic resources with partial resistance to sclerotinia stem rot (SSR) in canola, as well as carried out key research into the impact of narrow windrow burning of canola stubble as a way to reduce the carry over of inoculum of the disease into following seasons.

Ascochyta blight in pulses are also on the CCDM hit list and our researchers are continuing to delve deeper into better understanding pathogen populations within Australia. Across all of our research areas, we continue to collaborate on key research projects both within Australia and globally, and as part of that, we launched the inaugural National Fungicide Resistance workshop held in Adelaide and partnered once again with the Australian Herbicide Resistance Initiative (AHRI) to stage the third Crop Protection Forum at Dalby in Queensland.

Again, our team was out and about at conferences, workshops, field days and expos, listening – and learning – from growers and industry partners and, in return, sharing valuable knowledge to help them identify and tackle disease, and better manage crops.

We also celebrated a very special birthday when our flagship citizen science project Mildew Mania turned five! More than 16,300 Western Australian students across more than 220 primary and high schools have taken part since this project began, helping our scientists tackle powdery mildew in barley – a disease costing Australian farmers up to $100 million in crop losses and fungicide control every year.

While all this was going on we also took the opportunity to look ‘inwards’ in our quest to ensure that what we’re doing, and how we’re doing it, is meeting everyone’s expectations. The first stage of this investigation was to use a ‘Most Significant Change’ approach, where we asked other researchers and industry to provide feedback – via an independent consultant – on our research and its impact, in a bid to help us streamline our current activities and plan for the future.

We’re pleased to say the feedback so far has been encouraging and we’ve shared some of this on page two (opposite).

We believe we’re on a trajectory to continue the delivery of high quality research and development outcomes for industry.

Mark Gibberd and Karam Singh
Foliar fungal disease poses a huge threat to Australian growers, placing their crops and their livelihoods at immense risk. If fungicides used to treat these diseases are ineffective, the impact at the farm level can be severe. Our research is aimed at discovering more about fungicide resistance in crops so we can help develop tools for growers to prevent, mitigate and minimise its occurrence and impact.

Some key activities and achievements

- Using the baiting trial network, in conjunction with the high throughput technology of our digital Polymerase Chain Reaction (PCR) machine, we identified new cases of fungicide resistance in wheat powdery mildew and barley powdery mildew. This brings us a step closer to securing an early warning monitoring system for fungicide resistance.
- Testing of samples uncovered resistance in the common barley disease spot form of net blotch (SFNB) to DMI (Group 3) fungicides in Western Australia’s southern regions (read more in our case study).
- We also discovered new and higher-level cases of resistance in net form of net blotch samples (NFNB) in various regions across WA. Sampling and testing is ongoing in 2018.

In December 2017, the inaugural national fungicide resistance workshop was initiated by the CCDM, with the aim of gathering experts in fungicide resistance, together with agrochemical companies and representatives from Australia’s key funding and regulatory bodies.

As part of this workshop a number of industry-agreed principles for the management of fungicide resistance were established including an update in ‘terms’ used to define fungicide resistance by the Fungicide Resistance Action Committee (FRAC).

- **Definition of ‘fungicide resistance’** – it was agreed that the term ‘fungicide resistance’ should be defined using a field perspective as follows: *Fungicide resistance* – when a previously effective fungicide fails to control a disease resulting in field failure.

In addition, discussion also centered around the need to determine the impact of the use of low and high rates in the management of fungicide resistance as well as the need for improved extension of this topic to growers and advisors.

Follow-up meetings are now in planning to enable continued discussion and collaboration on key fungicide resistance matters.
CASE STUDY: FINDING NEW RESISTANCE

Researching crop disease is one part of our role, offering advice to farmers on how to deal with it is another and when you can combine the two, that’s where the CCDM really has added impact.

For grain growers across Australia the discovery of resistance in the common barley disease spot form of net blotch (SFNB) to DMI (Group 3) fungicides was a major research outcome in 2017, prompting a call to growers to implement integrated disease management strategies and a good fungicide application plan.

The resistance was discovered in samples from paddocks in Western Australia’s Esperance and South Stirling regions that had been sent in by officers from the Department of Primary Industries and Regional Development.

Lab tests by CCDM researchers confirmed SFNB (Pyrenophora teres f. maculata) resistance to DMI fungicides, such as tebuconazole, which is primarily used for the control of barley powdery mildew.

CCDM researchers used high throughput technology (digital PCR) to help quickly diagnose the resistance, building on previous advancements in this technique by CCDM researchers.

The findings were communicated to industry to help them plan their management strategies and further testing of samples will continue across 2018.

Looking ahead – 2018

• Identify and analyse new compounds that can be used for the screening of our fungal collections.
• Further investigate the potential of the high throughput technology for the rapid analysis of field samples.
• Continue research activities on management options for pathosystems under threat from fungicide resistance, with a focus on emerging DMI fungicide resistance in net form of net blotch in barley.
• Continue to investigate and identify the molecular mechanisms controlling resistance found in Australia, which will improve detection methodologies and anti-resistance strategies.
• Plan and deploy new baiting trials, and the collection of field samples from each of the trials and project collaborators.

Virginia Wainaina, PhD student

Virginia completed a Masters research at CCDM in 2016 with the CCDM’s Fungicide Resistance Group, before receiving a PhD sponsorship to continue her research work with the sclerotinia team at CCDM.

In 2017, Virginia was runner-up in the Young Professionals in Agriculture Forum for research she carried out into fungicide resistance using the Loop Mediated Isothermal Amplification (LAMP) technology.

“Undertaking my Masters research under CCDM’s Fungicide Resistance Group was the best thing that ever happened to my life. The opportunity built my research capabilities and confidence as a young researcher.”
Using modern technologies to study the structure and function of genes at a molecular level, CCDM researchers are able to better understand and predict the pathogens that cause common crop diseases. With this information, they then work to develop strategies to better protect growers against disease impact and provide breeders with the genetic tools to improve resistance in crops including:

- Septoria nodorum blotch of wheat
- Net blotch of barley
- Powdery mildew of barley
- Sclerotinia stem rot of canola
- Ascochyta blight of pulses

Central to our research is the use of bioinformatics, a technique that involves the collection and analysis of genomes (or genetic codes) of fungal pathogens. These genomes provide valuable insight into host-pathogen interactions and the evolution and adaptation of pathogens. Our team is also at the forefront of identifying new ways to computationally predict genes that cause wheat disease.

Some key activities and achievements

- We have developed new Australian genomic resources in the fight against yellow spot disease, uncovering genetic features that haven’t been seen before that will allow Australian researchers to be more effective in studying the disease.

- Collaborated with Dr Lee Hickey in a QAAFI-led study to identify good sources of septoria nodorum blotch and tan/yellow spot resistance in wheat. This led to identifying a strong correlation between disease susceptibility and effector sensitivity (read more in our case study).

- We tested 40 Australian wheat varieties for disease susceptibility to yellow spot using a ToxA deleted mutant strain and uncovered evidence of new yellow spot effectors in Australia.

Catherine Rawlinson, PhD student

Catherine started as a PhD student in early 2016 with a focus on specialised metabolism. She is part of CCDM’s Yellow Spot of Wheat program working to dissect the plant-pathogen interaction to supply wheat breeders with markers for disease resistance.

“Studying at the CCDM has allowed me to expand my skills as an independent researcher with the encouragement and support of my supervisors. Additionally, working face to face with a diverse and expert team in the Centre has broadened my knowledge well beyond my own project.”
• Using genome sequences for net form of net blotch in barley (NFNB), we identified potential causal effector genes responsible for phytotoxicity, or destruction of plant tissue, in barley and will investigate these further into 2018. In parallel, we screened exotic germplasm to identify new NFNB resistance genes and are developing populations to provide selective markers to breeders.

• High quality net blotch genome assemblies have been created as a valuable tool for discovering new fungicide resistance mutants and mechanisms, as well as for genetic mapping by Australian researchers.

• Our barley powdery mildew research involved using disease screens, genetic mapping barley populations and molecular techniques to identify durable resistance (genes with resistance to all mildew pathotypes). Building on previous successful isolation of a durable resistance, we have now identified additional broad-spectrum exotic resistance genes with the intention of providing alternative long-term resistances to breeders.

• Compared the genome sequences that cause Ascochyta disease in lentils and discovered a large insertion of genomic sequence that carries a likely virulence gene. We are now working toward further identification of these genes using genetic populations provided in collaboration with researchers in South Australia.

• Identified germplasm with partial resistance to sclerotinia stem rot (SSR). Our studies also determined that WA SSR isolates are a distinct population to that of Europe, USA and Canada, which provides clarity and relevance to Australian research. We also looked at the environmental factors causing basal infection of canola.

Looking ahead – 2018

• Continue to screen barley germplasm for new resistance to NFNB and develop two genetic populations for determining the genes involved in new disease resistance. We’ll also continue our work in identifying phytotoxic activity/candidates, and collaborate with international partners to examine host resistance.

• International collaborations screening various wheat genetic mapping resources for sensitivity to tan (yellow) spot and septoria nodorum blotch.

• Initiating the use of metabolomics to better understand small molecules important in yellow spot disease.

• Collect sclerotinia isolates Australia-wide to determine population structure compared to the global population.

CASE STUDY:
FROM RUSSIA WITH LOVE

Collaborations are an essential component in research and CCDM was able to tap into new wheat mapping populations and genotypes thanks to a partnership with Queensland Alliance for Agriculture and Food Innovation (QAAFI) researcher Dr Lee Hickey.

A highly prized addition to the CCDM’s collection was a panel of a genetically diverse wheat variety Dr Hickey had collected from the N. I. Vavilov Institute of Plant Genetic Resources in Russia.

The genetic diversity of the Vavilov line enabled researchers to make highly detailed investigations into the genes responsible for some common Australian crop diseases such as septoria nodorum blotch (SNB) of wheat, and learn more about how the fungus that causes SNB is able to infect its host and cause significant yield losses in many wheat-growing areas around the world.

The best locally available modern bread wheat cultivars in Australia only possess partial resistance to SNB. An important part of the CCDM’s work is to look for sources of strong resistance in wheat cultivars so that breeders can introduce them into modern bread wheat varieties.

In studying the Vavilov panel, CCDM researchers found that Vavilov wheats are a good source of SNB resistance. They also discovered a number of effectors responsible for SNB - ToxA, Tox1 and Tox3. Vavilov lines that are insensitive to these three effectors were significantly more resistant to SNB. Furthermore, genetic studies uncovered evidence of novel genes that can be stacked to further enhance SNB resistance.

The Vavilov panel was also used to look for resistance to the diseases rust and tan (or yellow) spot in wheat. The study identified a strong positive correlation between seedling tan spot and ToxA sensitivity. Vavilov lines that displayed high adult resistance to tan spot were also identified.
CCDM is working with growers and industry to develop economical integrated disease management (IDM) strategies to tackle fungal diseases. Our goal is not only to minimise the impact of fungal pathogens, but also to ensure that our stakeholders have the most up-to-date and relevant information on matters relating to crop protection and disease management, and can assess the best return on investment to crop protection.

Araz Abdullah, PhD student

Araz started his PhD in 2015 looking at wheat disease complexes, in particular, the leaf spot complex of yellow spot and septoria nodorum blotch. His research aims to better understand the leaf spot complex with the aim of developing disease management practices to control both diseases at the same time and improve outcomes for growers.

“My research with CCDM provides the opportunity for quality hands-on work that I know is having a real impact in the agriculture industry. I get to combine my lab-based research with getting out and into the paddock and meeting the growers and agronomists we are trying to help. I also get the chance to network with industry leaders, as well as benefit from the support of a really knowledgeable and passionate research team.”

Some key activities and achievements

- Multiple field trials in the WA Wheatbelt region to determine environmental conditions required for sclerotinia stem rot infection in canola (read more in our case study).
- Identified temperatures required to trigger germination of sclerotia from canola and lupins. Importantly, we have also examined how the triggers vary for populations across the landscape.
- The impact of narrow windrow burning of canola stubble after harvest on sclerotinia burdens has been shown to potentially be a useful non-fungicide tactic in reducing future sclerotinia incidence following severe infection.
- A range of remote sensing tools are being evaluated for disease detection. These include leaf hyperspectral imaging for early disease detection.
- Field evaluation of new and existing barley genotypes as potential means for management of the widespread DMI resistance to powdery mildew pathogen in WA and elsewhere.
- Evaluation of different management options (genetics and different mixtures of fungicide modes of actions) to control the emergent DMI resistance in barley net form of net blotch.
- Examined the spatial and temporal variation of in planta persistence of an in-furrow fungicide as a function of crop vigour. The results explain variation in performance of such products and highlight the complexity of modelling fungicide efficacy under field conditions.
- Delivered training to almost 200 future agronomists and researchers across four Australian universities, including five ‘Risky Business’ workshops on crop and disease management.
- Developed a farm and paddock scale decision support model to help improve the effectiveness of mid-season fungicide treatments. The model takes into account factors such as climate and market conditions that influence return on investment in crop protection tactics.
- Developed cost benefit analysis methodology to enable industry-level impact assessment of crop protection practices and innovations.

Ayalsew Zerihun investigating barley samples in field trials.

Linda Thomson sifts for sclerotes in soil from paddocks infected with sclerotinia.
Kyran Brooks, former Honours student

Kyran conducted trials into how windrow burning of canola stubble may also help growers manage the damaging fungal disease sclerotinia stem rot.

“Undertaking Honours research at the CCDM allowed me to work alongside some of Australia’s leading agricultural pathologists whilst also utilising the state of the art technology that the CCDM offers. Since entering the agriculture industry as an agronomist, my time at CCDM has provided me with the skills to understand scientific methods in-depth and to critically think about how new research can be appropriately included into everyday farming practices.”
2017

SENIOR STAFF AND PROGRAM LEADERS

Mark Gibberd
CCDM Co-Director
(Agronomy, Agribusiness and Centre Operations)

Karam Singh
CCDM Co-Director
(Scientific Programs)

Richard Oliver
CCDM Chief Scientist

Amir Abadi
Program Leader
Improved Farming Systems

John Noonan
Program Leader
Extension and Engagement

Kar-Chun Tan
Program Leader
Septoria Nodorum Blotch of Wheat

Caroline Moffat
Program Leader
Yellow Spot of Wheat

Simon Ellwood
Program Leader
Net Blotch and Powdery Mildew of Barley

Lars Kamphuis
Program Leader
Sclerotinia Stem Rot of Canola

Robert Lee
Program Leader
Pulse Pathology and Genetics

Fran Lopez-Ruiz
Program Leader
Fungicide Resistance Group

James Hane
Program Leader
Bioinformatics

Research Fellows / Associates

Ayalsew Zerihun, Research Fellow
Bernadette Henares, Research Associate
Cynthia Ge, Research Associate
Huyen Phan, Research Fellow
Jordi Muria Gonzalez, Research Associate
Katherine Zulak, Research Fellow
Lifang Liu, Research Associate
Madeline Tucker, Research Associate
Matthew Denton-Giles, Research Fellow
Mark Derbyshire, Research Fellow
Pao Theen See, Research Associate
Paula Moolhuizen, Research Fellow
Pippa Michael, Research Fellow
Robert Syme, Research Associate
Sarita Bennett, Senior Research Fellow
Weiwei Deng, Research Fellow

General staff

Jo Monaghan, Centre Administrator
Megan Jones, Extension Coordinator

Students

Araz Abdullah, PhD Student
Beren Spencer, PhD Student
Catherine Rawlins, PhD Student
Christina Andronis, PhD Student
Darcy Jones, PhD Student
David Lane, Honours Student
Evan John, PhD Student
Naghmeh Besharat, PhD Student
Stefania Bertazzoni, PhD Student

Technical staff

Alexandra Kay, Research Assistant
Belinda Cox, Research Assistant
Chala Turo, Senior Research Officer
Christina Grime, Research Assistant
Eiko Furuki, Research Assistant
Elyce Iagallo, Research Assistant
Emilie Perez-Wright, Research Assistant
Fiona Kamphuis, Research Assistant
Joe Lee, Research Assistant

Johannes Debler, Research Assistant
Julie Lawrence, Senior Research Officer
Kalai Marathamuthu, Research Assistant
Kane O’Driscoll, Research Assistant
Kasia Clarke, Senior Research Officer
Kejal Dodhia, Research Assistant
Kim Riley, Research Assistant
King Yin Lui, Research Assistant
Leon Hodgson, Research Assistant
Lina Farfan Caceres, Research Assistant
Lincoln Harper, Research Assistant
Linda Thomson, Research Assistant
Matthew McNee, Research Officer
Nikki Schultz, Research Assistant
Nola D’Souza, Senior Research Officer
Steven Chang, Research Assistant
Virginia Wainaina, Research Assistant
Vlad Piscetek, Research Assistant
Wesley Mair, Research Assistant
Yuphin Khentry, Technical Officer
Journal articles and book chapters


Why not jump on board and follow the team!

WANT TO KNOW MORE ABOUT US AND THE WORK WE DO?

The Centre for Crop and Disease Management
Curtin University
Kent Street, Bentley, WA 6102
GPO Box U1987, Perth WA 6845

CONTACT US
For general enquiries:
Jo Monaghan,
Centre Business Manager
T: 08 9266 5109
E: jo.monaghan@curtin.edu.au

For media, event or extension enquiries:
Carole Kerr, Extension Coordinator
T: 08 9266 4818
E: carole.kerr@curtin.edu.au

ccdm.com.au
ccdm@curtin.edu.au

@theCCDM www.facebook.com/theCCDM

Centre for Crop and Disease Management
GRDC Curtin University

ccdm.com.au