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GRDC

GROUNDCOVER SUPPLEMENT

GRAINS RESEARCH – THE NEXT GENERATION

THE GRAINS INDUSTRY'S TALENT QUEST

To deliver world-class grains research, development and extension, the Australian grains industry needs to attract and nurture the requisite talent. GRDC's approach is guided by the Grains RD&E Capacity and Ability Framework

By Craig Ruchs

Cultivating a passion for solving grains industry issues in the next generation of scientists is vital for building future capacity in the Australian grains industry. Attracting talent is a competitive business, so training, nurturing and motivating the world's best talent to participate in Australian grains research and development is key to delivering profitable solutions for Australian grain growers. This requires investment in capacity and ability (C&A) across the entire research, development and extension (RD&E) pipeline, not only in foundational science disciplines but also in communication, extension and commercialisation across both public and private sectors. To achieve this, GRDC invests in a range of approaches, guided by the Grains RD&E Capacity and Ability (C&A) Framework (https://grdc.com.au/about/rd-and-e-capacity-and-ability) principles. This framework is one of four in the GRDC 2018–2023 RD&E Strategic Plan. Its aim is to ensure targeted and impactful investment by GRDC alignment with the following three strategic elements:

1. attract and nurture talent required to conduct and deliver world-class grains RD&E;
2. support leadership and pathways to innovate, translate and adopt; and
3. facilitate access to critical infrastructure and technologies required to deliver grains R&D.

GRDC undertakes C&A building through its broader portfolio of RD&E investments, as well as targeted activities in specific programs, partnerships or initiatives. The focus is not only on talented research scientists but also includes growers and others involved in ensuring on-farm impact through communication, extension and commercialisation.

BROADER PORTFOLIO INVESTMENTS

While GRDC invests in targeted C&A activities to address specific needs or gaps, GRDC's greatest contribution to building scientific C&A is arguably through investment in its broader portfolio of research projects and programs. Both PhD and postdoctoral study opportunities can be either linked or embedded within major GRDC investments addressing priority issues including long-term strategic partnerships. These investments support access to leading scientists and cutting-edge facilities while working directly on priority constraints or opportunities to increase grower profit.

For example, in Western Australia, the Centre for Crop and Disease Management has a national role in reducing the impact of some of the major diseases in crop production. In Victoria, the Victorian Grains Innovation Partnership with Agriculture Victoria is centred around the world-leading research precinct in Horsham and programs of work aimed at increasing pulse profitability as well as bridging the profitability gap by taking a systems approach. In NSW, the Grains Agronomy and Pathology Partnership with the NSW Department of Primary Industries focuses on winter crop agronomy and pathology research.

TARGETED INVESTMENTS

Some of GRDC's targeted C&A investments include:

- development of primary and secondary teaching resources in partnership with other RDCs and the Primary Industries Education Foundation Australia;
- sponsorship of the Queensland Department of Agriculture and Fisheries Hermitage Research Facility Schools Plant Science Competition;
- AgriFutures Horizon Scholarships to support undergraduate studies;
- CSIRO summer vacation scholarships; and
- GRDC research scholarships to support postgraduate studies.

This *GroundCover*™ Supplement celebrates a selection of the young scientists, supported by GRDC, committed to delivering innovative research solutions to the challenges facing Australian grain growers. □

More information: Craig Ruchs, craig.ruchs@grdc.com.au
For information on targeted investments, go to https://grdc.com.au/about/rd-and-e-capacity-and-ability

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GRDC: 02 6166 4500, fax 02 6166 4599

WRITE TO: The Editor – *GroundCover*™, PO Box 5367, Kingston ACT 2604

EXECUTIVE EDITOR: Ms Maureen Cribb, manager, integrated publications, GRDC, 02 6166 4500

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COVER IMAGE: Dr Camilla Hill is undertaking a GRDC-supported post-doctoral study at Murdoch University. **PHOTO:** Evan Collis

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Pandemic delivers a win for local agriculture students

GRDC has a mandate to attract and nurture the talent required to deliver world-class grains research, development and extension. That talent can often abound with initiative

KEY POINTS

- Capacity building within the grains industry can have a broad reach into higher education
- Unravelling heat stress responses is fundamental to the adaptability of cereals and will guide future breeding efforts

■ As a keen traveller with an eye for training and research opportunities – underpinned by international accreditations and a fundamental interest in food crops – Dr Onoriode Coast is now in a position where he will teach Australian students agronomy and soil science.

Dr Coast honed his plant physiology skills working on two GRDC-invested projects that were collaborations between the University of Sydney, University of Newcastle, Australian Grain Technologies and the Australian National University (ANU), where he was based. The projects were related to each other as they both had a focus on heat stress in wheat.

"The postdoctoral fellowship, which I led, was designed to examine Australian wheat for tolerance of heat for a key plant trait – photosynthesis – with an end goal of helping breeders select better-yielding lines under heat stress," Dr Coast says.

"Through this project we found a set of wheat germplasm with great diversity in photosynthetic heat tolerance. We also identified adjustments that some wheat cultivars employ to maintain and even improve photosynthetic performance, when we focused on high night temperatures.

"As part of the research, we have fine-tuned a tool for large-scale screening of wheat genotypes and are providing breeders with physiological information to inform wheat performance under Australian heat stress conditions.

"In addition, we have identified promising wheat breeding material with stable photosynthetic high-temperature tolerance for a wide range of the Australian grainbelt."

ADAPTABILITY

Dr Coast's career is also a testament to adaptability and flexibility. Having completed a bachelor's degree with honours in agriculture, specialising in crop science, in 2007 at the University of Benin, Nigeria, he then completed a PhD from the University of Reading, UK, in 2012, with about half his time spent on research at the International Rice Research Institute in the Philippines.

"It was while undertaking my PhD that I focused on plant physiological response to stress; in this case it was high-night-temperature tolerance in rice," Dr Coast says.

"After the GRDC Fellowship at ANU, I joined the Natural Resources Institute (NRI) at the University of Greenwich, UK, as a senior research fellow in crop physiology in 2020, to lead NRI's crop physiology research in cropping systems of developing countries, mostly in Africa. But the global pandemic necessitated a rethink of my career plans and move to the UK.

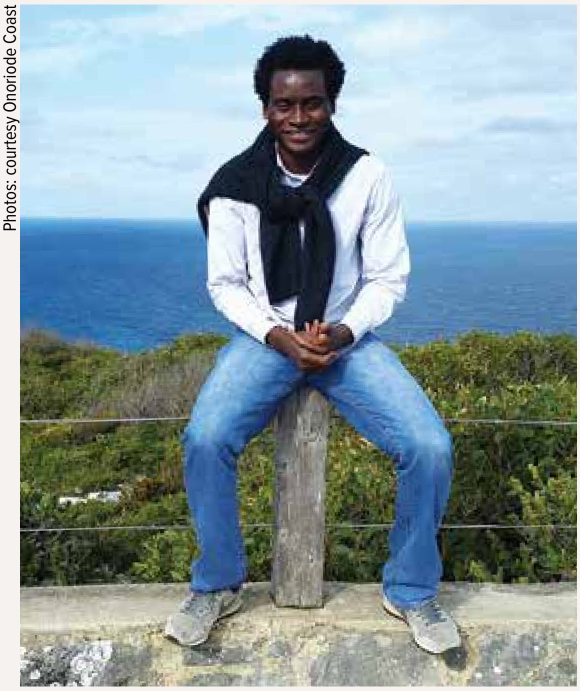
"Fortunately, and excitingly, I am starting a new position as a lecturer in crop science at the University of New England (UNE) in Armidale, New South Wales.

"In this role I will be strengthening UNE's research in sustainable plant production and horticultural science with a focus on controlled environments, and contributing to teaching and supervision of students in agronomy and soil science." ☐

GRDC Code UOS1904-003RTX

More information: Onoriode Coast, 0416 700 852, onoriode.coast@anu.edu.au

Photos: courtesy Onoriode Coast



With undergraduate qualifications from Nigeria, training from the United Kingdom and the Philippines and equipped with further skills from a GRDC-supported capacity-building project, Dr Onoriode Coast will soon be lecturing and supervising students in agronomy and soil science at the University of New England.

Dr Coast preparing wheat samples collected from a remote field site for cold storage and transport to the Australian National University for laboratory analysis.

Inspirational legacy ups the ante with phenology data

KEY POINTS

- Capacity building is contingent on the commitment of experienced scientific mentors
- The National Phenology Initiative provides an ideal forum for training crop physiologists and modellers

■ An inspiring grains scientist has been a significant influence for Max Bloomfield to pursue a career in the grains industry.

"My motivation to pursue a career in the Australian grains industry began in my first job after university as a research technician with CSIRO," Mr Bloomfield says.

"This motivated me to pursue further education and I returned to La Trobe University, where I had completed my undergraduate degree, to complete honours and then a PhD under the supervision of Professor James Hunt. His wealth of knowledge and passion for the grains industry has been a big inspiration."

Mr Bloomfield's experience is an example of the legacy of capacity building within the grains industry, supported by GRDC for nearly three decades. Professor Hunt was supported by GRDC to undertake his PhD on the ecology of a summer weed in 2005, while, in turn, one of his supervisors completed a PhD focusing on wheat phenology supported by GRDC in its formative years in the 1990s.

NATIONAL PHENOLOGY INITIATIVE

Mr Bloomfield's PhD forms part of the GRDC-invested National Phenology Initiative (NPI). The NPI is led by Professor Hunt of La Trobe University and involves a multidisciplinary team of research agronomists, molecular biologists, modellers and data scientists from CSIRO, NSW Department of Primary Industries, South Australian Research and Development Institute, Western Australian Department of Primary Industries and Regional Development, Statistics for the Australian Grains Industry and Plant & Food NZ.

The project's aim is to better predict phenology – in particular flowering time – of wheat and barley cultivars across the diverse Australian grains environments.

There is a need for more reliable sowing guides, particularly at the point of release of new cultivars, as these cultivars may be flowering outside the optimal period for their environment. The updated Agricultural Production Systems sIMulator (APSIM) Next Generation simulation software allows for crops to be parameterised with phenology data collected in controlled environments. This captures cultivars' responses to the environmental factors' photoperiod (day length) and vernalisation (extended exposure to cool temperature).

"My role in the NPI was to phenotype 96 Australian wheat and barley cultivars in four controlled environments – 17 or eight-hour photoperiods, with or without eight weeks' vernalisation at 5°C – and also assist in data collection in field experiments to validate the model," Mr Bloomfield says.

"We found that Australian wheat cultivars had much more diversity in their vernalisation and photoperiod responses, whereas Australian spring barley genotypes only responded to photoperiod."

The data collected is being used by the modelling team to derive parameters for each cultivar in the APSIM Next Generation software and predict time to flowering.

The use of controlled-environment data has improved the accuracy in predicting flowering time in the APSIM Next Generation wheat and barley models compared with the baseline APSIM Next Generation and APSIM Classic.

Controlled-environment data also reduces the time taken to collect parameterisation data from several years to a few months. Once complete, growers will have access to a web-based platform to better inform their cultivar-by-sowing-time decisions for their particular environments.

Mr Bloomfield's interest in cereal crop phenology was fostered while tending to wheat field experiments when he worked as a research technician for CSIRO in Canberra.

"In the final stages of my PhD I have taken up a role as an agricultural trials officer at Field Applied Research Australia, where I look forward to further building on my knowledge of cropping systems and provide sustainable and economic solutions to the grains industry." ☐

Photo: Dr Corinne Celestine, La Trobe University

Recording leaf numbers in a plot at the Melbourne Polytechnic Yan Yean farm, Max Bloomfield from La Trobe University has nearly completed a doctorate in philosophy as part of the GRDC-invested National Phenology Initiative.

Photo: Max Bloomfield, La Trobe University

Controlled-environment work completed to derive parameters as part of Max Bloomfield's contribution to parameterisation of the APSIM Next Generation model. This image shows long day length (17 hours); the bigger plants at the back are not vernalised and the little ones at the front are vernalised. They were just moved in from their eight-week cold treatment, hence the size difference.

GRDC Code ULA1806-004RTX

More information: Max Bloomfield, 0421 233 202, m.bloomfield@latrobe.edu.au, @Blooming_fields @agronomeiste

Legacy created for Australian mungbeans

■ A flair for creativity has proven to be a valuable attribute for Heather Pasley in pursuing a career in crop modelling.

Dr Pasley moved to Australia from the US in October 2020 to work on building an improved mungbean simulation model in Agricultural Production Systems sIMulator (APSIM) Next Gen.

This work, supported by GRDC and involving collaborations between La Trobe University and CSIRO, aims to improve mungbean agronomic recommendations to reduce climate risks and yield variability.

"My passion lies in crop model building, especially as it pertains to low-yielding crops in stressed conditions. Here in Australia, I have the privilege to work with and learn from an amazing group of growers, scientists and modellers," Dr Pasley says.

"I enjoy thinking about the whole cropping system – how every part is interwoven with the others. With modelling, I get to map out the complex interactions of the soil, climate and crop without losing sight of the big picture. Modelling lets me utilise my creative side, but at the same time build practical tools that can help growers and policymakers to make agriculture more productive, efficient and sustainable."

Dr Pasley brings experience working as a postdoctoral scientist on improving the earlier version of APSIM for soybeans and applies this to her task for Australian mungbeans.

MUNGBEAN MODEL

She explains that the mungbean model will be part of the larger cropping systems model – APSIM Next Gen – with which researchers can execute complex farming system experiments virtually to answer growers' practical questions about management strategies and cultivar selection as well as broader scientific questions about sustainability and climate change.

While there is a mungbean model in the older version of APSIM (APSIM Classic), this model reflected the limited knowledge researchers had about mungbeans at the time and was also based on outdated cultivars.

"This new model will incorporate a deeper understanding of mungbean growth and physiology (gained from recent GRDC-supported University of Queensland field studies) and take advantage of improvements made to the overall APSIM model."

Dr Pasley hopes the outcome for Australian growers will be greater confidence in what they can expect from a mungbean crop under different management schemes and climatic conditions. She says outputs from the model have the potential to provide insight into what sowing dates, water or irrigation regimes, and cultivar combinations are optimal for growers in different regions.

This work will generate legacy information for the grains industry that can be used in different projects into the future.

"Such information can be put into the GRDC GrowNotes™ and act as guidelines for farmers throughout Australia," she says. "The model can also provide a tool for mungbean breeders to test new varieties in more environments without having to spend more money on field trials."

CREATIVE NETWORKS

Dr Pasley holds an undergraduate degree in geology and anthropology and a doctor of philosophy in agronomy on nutrient cycling and cropping systems in Kenya and Zimbabwe.

With a keen interest in connecting to people and communicating her work, particularly to her non-agricultural family in the US, Dr Pasley has harnessed her creative skills to develop a regular comic strip to explain her research.

In the future, Dr Pasley has her sights set on developing crop models to help growers and researchers in sub-Saharan Africa improve their agricultural systems. But in the meantime, she will continue to expand her professional network and broaden her understanding of dryland farming systems in Australia. □

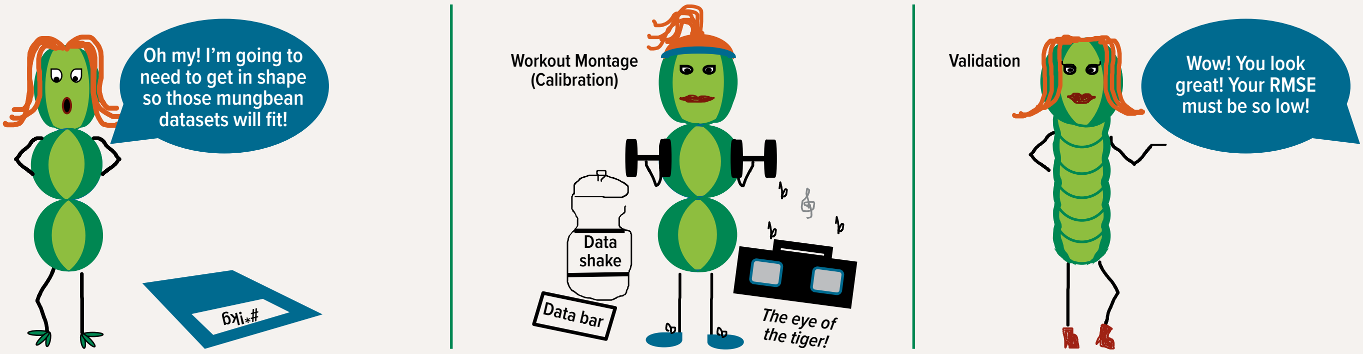
GRDC Code ULA1906-002RTX

More information: Heather Pasley, 0448 500 597, heather.pasley@csiro.au

Photo: Brett Cocks

Dr Heather Pasley is applying systems thinking to mungbeans to improve the widely used APSIM computer model for the Australian grains industry.

Source: Dr Heather Pasley



Dr Pasley's current work in the form of a comic. She is starting with the soybean model (panel 1) as a baseline and then rebuilding it to be a mungbean model (panel 3). In the third panel, RMSE (root mean squared error) is a statistical metric for how well the model fits the data (the lower, the better).

Synchrotron takes crop root studies to new levels

Detailed diagnoses of soil constraints, nutrient distribution and plant root-soil interactions are being explored using state-of-the-art science facilities

Photo: Brenton Edwards, Stories Well Told

Dr Casey Doolette developed an interest in the capabilities of synchrotron science in 2010 when she received a GRDC scholarship to perform experiments at the Stanford Synchrotron Radiation Lightsource and Australian Synchrotron to investigate the biofortification of wheat with foliar-applied selenium.

■ One of Australia's most significant pieces of scientific infrastructure – the Australian Synchrotron – is being put to use by an innovative three-state group of multidisciplinary researchers.

Three postdoctoral research fellows are working in a unique GRDC-supported collaboration with scientists at the synchrotron – a national research facility located in Melbourne – to generate new knowledge on soil-plant interactions. But COVID-19 lockdowns have provided additional challenges to establishing their collaborative network.

"Our project leaders – Professor Peter Kopittke from the University of Queensland and Professor Enzo Lombi from University of South Australia – have been extremely supportive of the three of us developing novel ways of sharing samples and analytical time across states," says Dr Casey Doolette, one of the postdoctoral scientists based at the University of South Australia.

Calcareous soil samples, exhibiting nutrient limitations, were extracted from the Eyre Peninsula, South Australia, and sent to Queensland for plant production and then to the synchrotron where the roots were examined at the imaging and medical beamline (IMBL – an X-ray imaging technique). The intact cores were then sent to SA, where they were sectioned and returned to Melbourne for another analysis. The samples have had to be screened for biosecurity as they cross state borders and have successfully dodged lockdowns themselves.

"The soil samples have travelled more than we have in our first year of operation, but it has meant we are well on the way to establishing necessary methods that will underpin future field-based analysis," Dr Doolette says.

Another of the postdoctoral scientists, Dr Han Weng, says the travel restrictions and lockdowns "limited team movement but not collaboration".

"I had to remotely start my University of Queensland role in Melbourne, while Dr Helen Hou worked from Brisbane (University of Queensland) but was supposed to start her secondment in Melbourne at the synchrotron. Being locked down in Melbourne allowed me to be the only team member to have physical access to the synchrotron during 2020. I was able to carry out two experiments on soil carbon and helped Dr Hou with her first two experiments on root structure, and I coordinated the logistics for Dr Doolette's X-ray fluorescence microscopy experiment to follow."

Dr Doolette says: "The spirit of scientific collaboration of scientists that use the synchrotron is a huge inspiration as we learn from techniques developed from different disciplines."

METHOD DEVELOPMENT

Dr Hou (University of South Australia and the University of Queensland) is using X-rays produced at the IMBL at the synchrotron to obtain three-dimensional images of roots growing directly within large soil cores – all without removing the roots from the soil in which they are growing.

Dr Hou works closely with Dr Doolette, who is investigating the corresponding distribution of available nutrients in these soils, while Dr Weng (University of Queensland) is investigating the interaction between soil organic matter and root growth.

Together, the researchers are developing new methods using the synchrotron that will then enable them to 'interrogate' more soil-plant samples to better understand the interaction between root growth, nutrient distribution and soil organic matter. The objective is to help improve crop management practices.

"Understanding the factors that limit root growth within soils is critical to improving crop yield and profitability. The IMBL allows us to use extremely high-intensity X-rays to examine the soil," Dr Hou says.

Although X-rays have previously been used to study roots in situ, the new faster and more sensitive approach at the Australian Synchrotron can examine roots in soil cores up to 20 centimetres in diameter – 10 times larger than previously possible – and down to considerable depths (50 to 100cm). Examining undisturbed root distribution in large soil cores allows more realistic and informative analysis.

ADVANCED ANALYSIS

Dr Doolette has developed an alternative means of analysing soil nutrient distributions using gel-based diffusive gradients in thin-film devices (DGT) and X-ray fluorescence microscopy (XFM) analysis.

Only nutrients that are potentially available for plant uptake accumulate in the gel layer. The DGT can then be analysed to measure nutrient concentrations and distribution in the roots and provide more reliable information on nutrient availability.

Dr Weng is conducting what is believed to be the first use of synchrotron-based soft X-ray and infrared techniques in soils: "We are examining how changes in organic matter within the soil – for example, changes due to cropping frequency or incorporation of green manures – are related to differences in soil properties and root distribution."

DIVERSE SKILL SET

The team brings a diverse skill set to generating new plant production knowledge in a variety of soils using the synchrotron.

Dr Hou holds a degree in information sciences and a PhD in information sciences from Tohoku University in Japan.

"My interest in robotics has led me to this research, with interests in image processing and control engineering. For this project, I can use skills in root segmentation and I can apply my knowledge regarding massive image processing, automated batch processing and parallel processing to hybrid root segmentation algorithms," Dr Hou says.

Dr Doolette, who has a degree in chemistry, has conducted synchrotron experiments since her honours project at the University of Adelaide, where she investigated the biofortification of wheat with foliar-applied selenium.

"For my PhD in environmental chemistry, I investigated the behaviour, fate and plant uptake of contaminants, specifically nanoparticles, in soil. Following my PhD, I worked for the Australian Government Department of Agriculture, Water and the Environment assessing the potential environmental risks of industrial chemicals."

Dr Weng holds a degree in environmental sciences from the University of East Anglia (UK) and has a keen interest in soil carbon, various soil ameliorants and their potential roles in climate change mitigation.

"During my PhD at the University of New England, I discovered the mechanisms to improve soil carbon retention in a pastoral system over a decade. Following my PhD, I worked on several GRDC subsoil constraint projects at the NSW Department of Primary Industries and La Trobe University," Dr Weng says.

The trio meets monthly, virtually, to discuss their findings and are excited to move on to the next step of analysing field-based soil cores to provide a step-change for growers' management practices. ☐

GRDC Codes USA1910-001RTX , UOQ1910-002RMX, UOQ1910-003RTX

More information: Helen Hou, h.hou@uq.edu.au; Han Weng, h.weng@uq.edu.au; Casey Doolette, 08 8302 6233, casey.doolette@unisa.edu.au; https://www.ansto.gov.au/about/what-we-do

Photo: Dr Chris Hall, ANSTO

Dr Helen Hou (University of South Australia and University of Queensland) has been integrated into the Australian Synchrotron imaging and medical beamline team, based in Melbourne, where she can access specialist synchrotron expertise for the benefit of the grains industry.

Photo: Dr Han Weng, UQ

Prolonged COVID-19 lockdowns have meant that a three-state team of postdoctoral fellows supported by GRDC to investigate root-soil interaction using the Australian Synchrotron in Melbourne have developed a novel collaborative network. Dr Han Weng (centre) is pictured at the Synchrotron Infrared Microspectroscopy beamline with Professor Peter Kopittke and Dr Brigid McKenna from University of Queensland.

Smart digital solutions for barley drought resistance

Machine learning has produced a way to improve the drought resistance of barley

■ Motivated by a need to speed up time-consuming conventional image analysis of plant stomata, Na (Charlotte) Sai, with collaborators from the University of Adelaide, has developed an automated approach using machine learning.

This has greatly improved techniques she requires for her PhD studies – supported by GRDC and supervised by Professor Matthew Gilliham, Dr Bo Xu and Dr Nathan Watson-Haigh – on barley drought resistance. Her research has a particular focus on stomatal guard cell function.

DYNAMICS OF BARLEY STOMATA

"Stomatal guard cells are the main 'gatekeepers' for gas exchange between plants and the atmosphere. They modulate the rate of photosynthesis – plant energy production – and transpiration, plant water loss," Ms Sai says.

"It is known that stomatal regulation can be affected by multiple factors including abiotic and biotic stress. Rapid accumulation of the key plant metabolite gamma-aminobutyric acid (GABA) in cells is an indicator of these stresses."

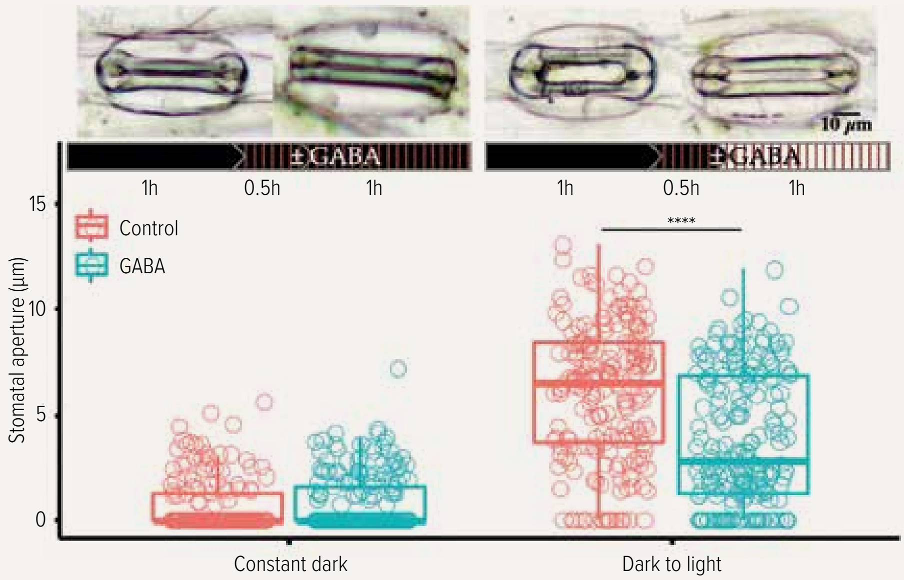
Photo: Na Sai, University of Adelaide

Na (Charlotte) Sai is using a combination of cutting-edge science and machine learning to decipher physiological and genetic components of drought tolerance of barley as part of a GRDC-supported capacity-building project at the University of Adelaide.

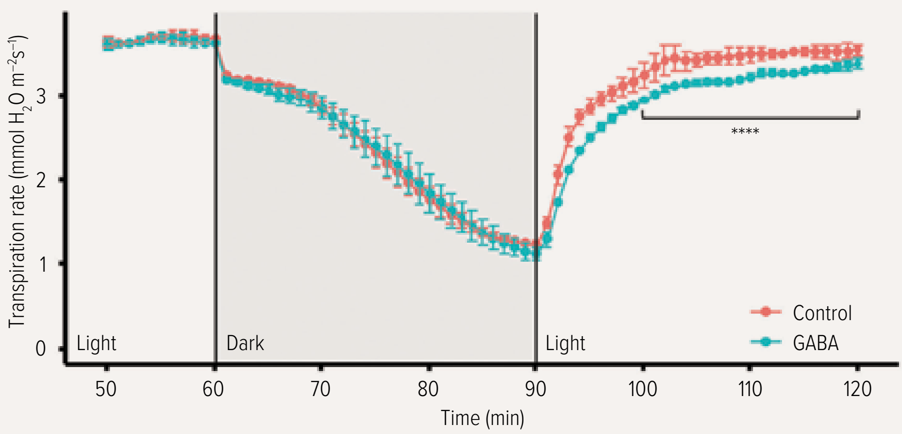
"IT IS HOPED THAT GABA REPRESENTS A NEW AVENUE FOR INFORMING PLANT BREEDING AND MANAGEMENT STRATEGIES TO IMPROVE WATER USE EFFICIENCY UNDER SUBOPTIMAL CONDITIONS, LEADING TO BETTER YIELDS UNDER A VARIABLE CLIMATE."

– NA (CHARLOTTE) SAI

Figure 1: GABA reduces stomatal opening and reduces water loss from barley.



Epidermal strips were incubated under dark for 1.5 hours followed by constant dark or a dark-to-light transition for an additional one hour as illustrated by white (light) and black (dark) bar.
The pre-treatment was applied 30 minutes before transition with or without 1mM GABA as indicated by the red vertical line (N > 170, **** p≤0.0001). Each stomatal image on top is a representation of the average stomatal pore size of each group.



Time-resolved water transpiration rate during the dark-light-transition of detached leaves (N = 3/group, **** p≤0.0001).

Source: Na Sai, University of Adelaide

Ms Sai has found that barley stomatal movement is indeed regulated by GABA. In particular, externally applied GABA suppresses light-induced opening.

"I found that small concentrations of GABA did not elicit stomatal movement by itself, unlike traditional drought signals such as abscisic acid. Instead, GABA inhibited the extent to which stomata open each day, limiting water loss but not inhibiting photosynthesis."

Transgenic and non-GM gene-edited barley with modified GABA metabolism have been produced and will be analysed after the completion of her project, when stable lines are ready, to assess their water use efficiency and drought resilience.

"It is hoped that GABA represents a new avenue for informing plant breeding and management strategies to improve water use efficiency under suboptimal conditions, leading to better yields under a variable climate," Ms Sai says.

Ms Sai has been working with researchers at the University of Adelaide's Australian Institute for Machine Learning to produce a trainable artificial intelligence algorithm to automate stomatal aperture measurements.

"The output of this is a deployable, user-friendly, open-sourced software package that will have broader scientific application as it can measure apertures and areas of barley and other plant stomata in a fraction of the time as performed manually, saving researchers many hours."

MULTI-SKILLED

Ms Sai completed a bachelor's degree in bioengineering in China in 2013 and came to Australia for a master's degree in plant biotechnology. Here, she developed interests in bioinformatics and programming before undertaking her PhD.

"From this point on, I wish to keep developing the automated imaging tool – 'StomaAI' – for increased functionality, to gain more experience and knowledge in artificial intelligence tools and develop a career in smart digital agriculture," Ms Sai says. □

GRDC Code UWA1708-010RTX

More information: Na (Charlotte) Sai, 0487 991 817, na.sai@adelaide.edu.au

NEW TOOLS FOR WHEAT SALT TOLERANCE

New scientific tools are being deployed in a capacity-building project to improve the salt tolerance of wheat

Photo: Evan Collis

Bhagya Dissanayake from the University of Western Australia is studying the molecular mechanics of wheat roots to provide new insights to boost salt tolerance of wheat.

■ A keen interest in proteomics – the science enabling researchers to understand complex molecular mechanisms related to plant metabolic processes – underpins Bhagya Dissanayake's grains PhD.

"I am studying how the metabolic machinery of wheat roots changes under salinity stress conditions," she says.

"Dryland salinity is a major environmental challenge for Western Australia, with the loss of agricultural productivity due to salinity damage estimated to be at least $519 million per year."

In 2018, Mrs Dissanayake was awarded a PhD scholarship supported by GRDC to undertake research in the Australian Research Council Centre of Excellence in Plant Energy Biology at the University of Western Australia, supervised by Professor Harvey Millar, Professor Rana Munns, Dr Christiana Staudinger and Dr Nicolas Taylor.

This followed completion of her honours degree in plant biotechnology in 2017 at the University of Sri Jayewardenepura, Sri Lanka. In her final year she conducted research to produce a polyclonal antiserum to detect a local virus strain that affects chilli plants in Asian countries.

NEW SCIENCE INFORMS APPROACH

To improve salt tolerance in wheat, most strategies have focused on breeding for sodium transporters to keep the salt in the roots and thus protect the shoot. But this does not factor in how salt affects the roots themselves.

"This is striking, as the root is the first tissue that is in contact with salt and it's the tissue responsible for nutrient uptake and ultimately driving plant growth."

To further improve salt tolerance, Mrs Dissanayake is investigating new molecular markers associated with the complex traits governing root tolerance to salt.

"I have made detailed measurements of the temporal and physiological responses of wheat showing that the root responses are distinct from the shoot responses," she says.

"I have built a detailed database using proteomics showing how hundreds of different proteins change within the roots of Australian commercial wheat varieties and other wheat genotypes with different levels of salt tolerance."

This shows how the complex trait of salinity tolerance in wheat develops in the tissue that is first exposed to salt. With this information and her expertise, Mrs Dissanayake can now predict which genes would need to be altered to increase root salt tolerance.

"I have also built assays that can be used to analyse new wheat varieties to assess how well their roots are tolerating salinity, which is beneficial for Australian wheat growers.

"Improvement of wheat root salt tolerance can complement existing work to exclude salt from shoots. The two traits can be stacked together to further reduce wheat yield losses in the future.

"We can then use marker-assisted conventional breeding – Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) – or other genetic methods to stack these traits together and then test the combined power of shoot exclusion and root tolerance in the field," she says.

Mrs Dissanayake intends to build on her experience and work collaboratively with academics, industry and growers to produce better crops for the future. □

GRDC Code UWA1708-010RTX

More information: Mrs Bhagya Dissanayake, 0456 733 970, bhagya.dissanayake@research.uwa.edu.au

Modelling better tillage tools

An innovative form of computer modelling known as discrete element method is providing an opportunity to simulate machine setting scenarios to develop a performance index for soil amelioration equipment

■ Tillage equipment used to ameliorate problematic soils, including mouldboard ploughs, two-way disc ploughs and rotary spaders, are often tested for efficacy in mixing soils in field trials but optimising performance can be expensive and limited in terms of the number of scenarios assessed.

Photo: Courtesy Dr Mustafa Ucgul

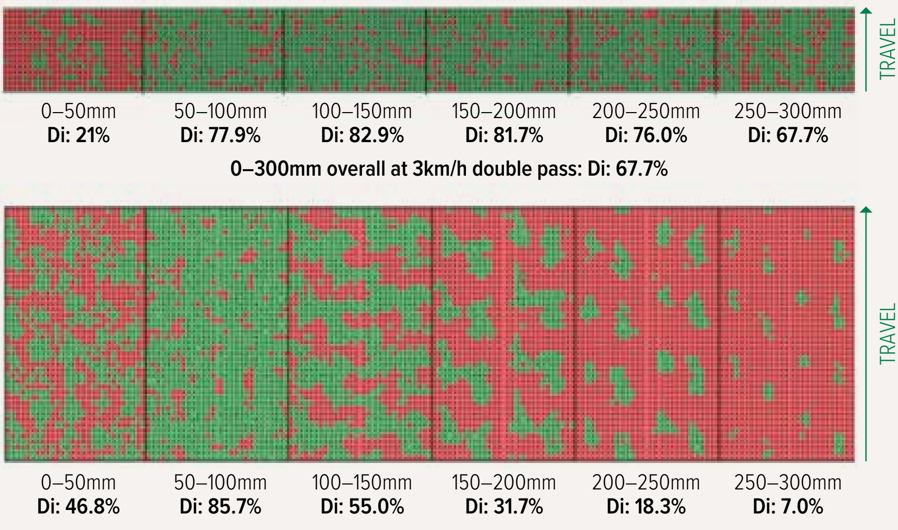
Dr Mustafa Ucgul, University of South Australia, seeding trials as part of a GRDC-supported capacity-building project focused on evaluating soil amelioration equipment performance.

Dr Mustafa Ucgul brings extensive training to this evaluation task. He holds a bachelor's degree in science and a master's in science in agricultural machinery from universities in Turkey, a master's in mechanical engineering from the University of South Australia, together with a PhD in soil-tool interactions using discrete element modelling (DEM).

Together with Dr Jack Desbiolles and Dr Chris Saunders at the Agricultural Machinery Research and Design Centre (University of South Australia), he is collaborating with Dr Lynne Macdonald (CSIRO) and Trengove Consulting (Bute, SA) to complete a GRDC-supported research fellowship investigating rotary spader operation using DEM to see how mixing uniformity is controlled and affects crop responses to different amendments.

Field trials over two years examined whether crop yield responses could be improved by optimising lime mixing in acidic soils, and animal manure incorporation in soils with poor organic matter content. The studies were complemented with DEM simulations.

Figure 1: Computer simulation results showing visual representation of the mixing uniformity of lime within a spaded soil profile, by 50mm thick soil layer. The area represents 4 blade width x 4 bite length seen in a top view in the direction of travel. NB: Green indicates soil zones containing lime and red indicates soil zones without lime. The Di value quantifies the green proportions of the soil volume.



Source: University of South Australia/AMRDC

LIME EXAMPLE

The lime trial on an acidic site compared various spading treatments, high mixing uniformity (two passes at 2.4 kilometres per hour), medium mixing uniformity (one pass at 5km/h, common grower practice) and low mixing uniformity (one pass at 9km/h). Results over two years show surface spreading up to 6.6 tonnes lime per hectare – without mixing – did not achieve any significant impact on crop vigour or yield.

"However, spading of lime treatments increased crop vigour up to 52.7 per cent in year two, relative to the control," Dr Ucgul says.

Barley grain yield in year one increased by 0.37t/ha (8.7 per cent over control) when lime was incorporated by spading, but only in high uniformity mixing treatment. This benefit was also maintained in year two when lentil was grown, with 37 per cent greater biomass in the high uniformity treatment. Grain yield responses were not statistically significant, presumably due to harvest losses.

"The data to date indicates that lime should be incorporated through the profile and mixed thoroughly for the most rapid crop response."

DEM simulations quantified extent and uniformity of amendment mixing under various soil and machine scenarios and developed a mixing index (Di) to provide an accurate basis for comparing treatments and correlating to crop responses.

Figure 1 shows simulation results when surface-applied lime is mixed through zero to 300-millimetre depths with 50mm resolution. The percentage of spaded soil volume containing lime, the Di value, ranged between less than 10 per cent at depth to greater than 80 per cent in shallow layers.

A much greater soil volume (Di >80 per cent) was achieved following a two-pass spading operation at 3km/h.

"I'm motivated to improve existing tillage tools for the Australian grains industry and also assist agricultural machinery manufacturers," Dr Ucgul says. □

GRDC Code USA1903-002RTX

More information: Dr Mustafa Ucgul, 0433 463 916, mustafa.ucgul@unisa.edu.au

Northern research goes to the root of the matter

The understanding of root–soil interactions in northern Australian environments will be improved through a GRDC capacity-building project

Photo: Dr Nelly Raymond, UQ

Bringing international agronomy and farming systems experience with him from Europe and Africa, Dr Frederik van der Bom at the University of Queensland is now seeking production gains for northern Australian systems through improving knowledge of root architecture to develop resource-efficient crops. He is a recipient of a GRDC-supported Capacity Building award.

■ A keen interest in tropical cropping systems compelled Frederik van der Bom to explore research opportunities in Kenya and Tanzania. But he says Australia is where the ultimate challenge is, since it is where production constraints abound.

With GRDC investment, he is working with Professor Mike Bell and Dr Alwyn Williams at the University of Queensland examining root architecture to develop more resource-efficient crops for dryland northern Australian environments.

The root–soil interface is the new frontier in which science is seeking production gains.

"Narrow, deep-root systems are expected to improve water and nitrate capture in dryland environments such as Australia," Dr van der Bom says.

"However, there is still a dearth of information demonstrating how these plant attributes contribute to resource uptake, and whether they will actually confer benefits in northern region growing conditions, in particular.

"It is these gaps in knowledge that my research is addressing with rhizoboxes, large soil columns and field experiments."

INSIGHTS

Dr van der Bom says wheat and sorghum lines bred for specific traits such as a wide or narrow root angle are being assessed in conditions of spatially separate water and phosphorus distributions, which commonly occur in the northern region. Particular attention is being paid to how these lines react to these complex conditions.

"Some root architectural patterns relating to soil profile exploration and the plants' ability to find soil resources are becoming evident. But we also see that without adequate phosphorus nutrition, root growth is limited, and these predefined root patterns essentially do not express anymore."

Applying starter phosphorus early could alleviate this and boost early root growth, soil exploration, resource uptake and, subsequently, crop performance. However, interactions and trade-offs are also evident.

"Take, for example, plants with a wide root system that might be better at scavenging a phosphorus-rich topsoil. This advantage quickly disappears as topsoil dries," Dr van der Bom says.

"Similarly, under some conditions, narrow root systems reach a deep phosphorus band somewhat quicker, which could be beneficial to get some phosphorus in the crop early. However, we also see more variation, with some plants seemingly 'missing' the band, going right past it.

"Ultimately, though, I think we are seeing root traits can deliver productivity benefits under specific conditions. The challenge is to assess which cropping systems are most likely to benefit from which traits."

Dr van der Bom brings a unique skill set to the task, with bachelor's and master's degrees from Wageningen University, Netherlands, specialising in international land management and crop science.

"During this study, I ran field experiments across the Rift Valley Province of Kenya and completed a research internship in Tanzania. In both cases, I aimed to identify farming constraints and to test the potential for increasing reliance on nitrogen fixation in smallholder systems.

"Subsequently moving to Denmark to do my PhD at the University of Copenhagen, I focused on how current and long-term nutrient management affects crop resilience under nutrient and environmental stress and developed an interest in phosphorus nutrition."

It was this interest that led to his move to Australia, after he established contact with Australian nutrition researchers during his PhD. While focused long term on an international academic career, Dr van der Bom says his immediate goal is the development of a robust research portfolio that delivers for Australian grain growers. □

GRDC Code UOQ1805-005RTX

More information: Frederik van der Bom, 0490 056 184, f.vanderbom@uq.edu.au

Genetic detective on the mouse trail

A capacity-building project for the grains industry is combining ecological and genetic skills to monitor and map mouse populations

An abundance of food following bumper grain seasons can often be a catalyst for mouse plagues, but mitigating the effects of mice on grain production is not simple. It is contingent on understanding how pest populations are structured across the landscape, how far and from where mice are moving and the extent to which geographic features facilitate or impede mouse movement.

Dr Kevin Oh is an evolutionary ecologist based at Macquarie University Applied BioSciences and CSIRO. He brings a particular skill set to investigating the life and habits of mice in Australian landscapes to better inform management practices.

"Better forecasting should improve farmers' ability to prepare for impending mouse plagues. But this research also aims to understand how mice are moving through the landscape and, in particular, how different landscape features might impede or facilitate mouse movement," Dr Oh says.

"As an example, we might be interested to know if adjacent bushland or pasture makes it easier or harder for mice to move between paddocks."

With a keen interest in genetics and genomics, local adaptation and conservation biology, Dr Oh applies concepts from evolutionary biology and population genetics along with modern whole-genome sequencing and bioinformatic analyses to address problems in invasive species management.

He has applied these primarily in wildlife conservation and development of new biocontrol techniques, in both vertebrate and invertebrate animal systems.

GENETIC TOOLS

He explains that advances in modern DNA sequencing techniques have made it possible to address such questions across broad geographic scales at the whole-genome level. This enables the resolution of fine-scale population genetic structure and gene flow, and may also provide insights into functional genetic variation that could inform the development of future control measures. In this project, Dr Oh is utilising whole-genome sequencing to identify genetic boundaries among mice sampled at long-term monitoring sites in cereal cropping regions.

"We have obtained DNA from hundreds of mice from sites in New South Wales, Victoria and South Australia, with plans for more sampling this spring in areas of NSW and Queensland impacted by recent plagues. In addition, we have developed new streamlined laboratory protocols for rapid and cost-effective genetic assays to support future mouse monitoring efforts.

"Preliminary analyses indicate only weak genetic differentiation among mice in different cropping regions, suggesting mouse populations are likely to be frequently interconnected."

Ongoing work aims to understand the extent to which these connections may contribute to mouse population fluctuations. This knowledge will contribute to improving the next generation of mouse plague forecasting.

Dr Oh says the genomic database being built could also be used in the future to develop new direct control methods – for example rodenticides or genetic biocontrol technologies.

His research has crossed domains from working in conservation and natural resource management as a scientist with the US Geological Survey and the US Department of Agriculture to applying his expertise in agricultural production systems. But he has maintained a specific focus on invasive pest species.

"I am keen to continue developing new tools and resources to support efficient and effective management of invasive pest species. It is my hope that this GRDC-supported work will form a key basis for the next generation of pest management strategies."

Photo: Dr Peter Brown, CSIRO

Dr Kevin Oh capturing mice for genome sequencing to inform potential plague forecasting via improved knowledge of population genetic structure and mouse movement.

> "BETTER FORECASTING SHOULD IMPROVE FARMERS' ABILITY TO PREPARE FOR IMPENDING MOUSE PLAGUES. BUT THIS RESEARCH ALSO AIMS TO UNDERSTAND HOW MICE ARE MOVING THROUGH THE LANDSCAPE AND, IN PARTICULAR, HOW DIFFERENT LANDSCAPE FEATURES MIGHT IMPEDE OR FACILITATE MOUSE MOVEMENT."
>
> – DR KEVIN OH

GRDC Code CSP1908-002RTX

More information: Dr Kevin Oh, 0476 145 696, kevin.oh@csiro.au

Genetic solution to barley heat stress

Photo: Evan Collis

Dr Camilla Hill, Murdoch University, preparing barley seeds for analysis by a SeedCount Analysis System to determine the effects of heat stress as part of her GRDC-supported postdoctoral study. SeedCount digital imaging systems use software and flatbed scanner technology to rapidly and accurately analyse grain samples and determine their physical characteristics – including grain plumpness, thousand kernel weight and screenings – which can be affected by stress.

Heat stress is a major production constraint in dryland agriculture and is set to become more prevalent as the climate changes – but for cereals a genetic solution may be at hand

KEY POINTS

- Internationally acquired skills are being combined with GRDC capacity-building investment to find solutions to barley heat stress
- Earlier flowering genetics have been found to be a successful strategy to mitigate heat damage and deliver higher grain fertility, grain yield and grain quality
- New genetic material and molecular tools will be available to Australian breeders to improve barley heat tolerance

■ For cereals, the floral developmental stage is very sensitive to high temperatures, which can cause structural and functional abnormalities to reproductive organs resulting in decreased fertility, seed-set and significant yield losses.

Management strategies include changing sowing date or crop type, but a genetic solution may also be achievable.

Dr Camilla Hill brings a breadth of experience to this task via a GRDC-invested capacity-building project. Originally from Germany, she had close connections with her grandparents' farm in Poland. Her introduction to life in Australia was working as a backpacker on farms in South Australia and Queensland before undertaking a PhD at the University of Melbourne in wheat genetics in 2010. Her doctorate was supervised by Professors Antony Bacic and Ute Roessner within the Australian Centre for Plant Functional Genomics and supported by three University of Melbourne scholarships.

"My childhood interest inspired me to study biology at the Free University of Berlin, where I took a major in plant genetics and minors in plant physiology, molecular biology and biochemistry. As part of this study, I spent nine months conducting laboratory work for my master's degree at Washington State University, funded by a German Academic Exchange Service Fellowship," Dr Hill says.

FOCUS ON ENVIRONMENTAL STRESSES

During her PhD, she investigated physiological and biochemical traits, as indicators of drought tolerance, in a wheat mapping population grown under drought stress. She was keen to shift the focus of her research to the practical application of genetics to plant breeding.

Dr Hill joined Professor Chengdao Li's team at Murdoch University's Western Crop Genetics Alliance in 2015 on two consecutive GRDC-supported projects. Her current project aims to provide valuable information on heat-tolerant phenotypes and genotypes for spikelet fertility in response to heat stress, and to deliver new genetic resources to Australian barley breeders.

"Genetic variability in spikelet fertility can be used by breeding programs to develop heat-tolerant genotypes. However, although considerable genetic variation for spikelet fertility has been reported in rice and wheat, comparatively little is known in barley and no candidate genes or molecular markers have been identified. This is the focus of my work," Dr Hill says.

KEY RESEARCH FINDINGS

More than 7000 genetic variants across 132 spikelet fertility and heat-tolerance-related genes have been identified. This information will allow the identification of new markers to breed barley varieties with enhanced spikelet fertility under heat stress.

Glasshouse trials, combined with heat chambers and field trials, have been conducted using 500 barley varieties from around the world.

"We found that in both the glasshouse and the field, earlier-flowering genetics were successful strategies to mitigate heat damage and resulted in higher grain fertility, grain yield and grain quality traits," Dr Hill says.

Based on decreases in spikelet fertility at high temperature, cultivars Flinders⏀, Vlamingh and La Trobe⏀ were most tolerant (two to six per cent reduction), while cultivars Grimmett and Oxford were highly susceptible (17 to 30 per cent reduction) and cultivars Sloop, Sloop Vic and Skiff were moderately susceptible (eight to 13 per cent reduction) to high temperature.

The genetic material and molecular tools from both projects will provide new resources for breeding for best phenology adaptation, high grain yield, high spikelet fertility and improved heat tolerance. ☐

GRDC Code UMU1903-004RTX

More information: Camilla Hill, 0431 612 819, camilla.hill@murdoch.edu.au

Phase rethink to aid weed and pest management

Photo: Evan Collis

Dr Yaseen Khalil from the Australian Herbicide Resistance Initiative (AHRI) at the University of Western Australia is investigating whether disruptive pasture sequences could provide opportunities to improve weed and soil-borne disease management in Western Australian cropping systems.

KEY POINTS

- Growers have provided input into a project to improve weed and disease management with disruptive pasture phases
- Multiple management tactics are required to reduce weed populations in these pasture phases

Crop rotation is an age-old practice to minimise pests and diseases, reduce chemical use, aid in building and maintaining healthy soil, and manage nutrient requirements – all of which maximise yield potential. But to ensure that Australian farming systems continue to improve their profitability and durability, a new lens is being focused on crop sequences.

Dr Yaseen Khalil is quantifying the agronomic and economic benefits of disruptive pasture phases as part of a capacity-building project through GRDC-investment with the Australian Herbicide Research Initiative (AHRI) at the University of Western Australia (UWA).

"I grew up working on my family farm in north-east Syria, where I developed a fascination for agriculture and food production," Dr Khalil says.

It led him to complete a bachelor's degree in agriculture in 2007 and master's degree in the history of applied science in 2012 at the University of Aleppo in Syria.

He joined the International Center for Agricultural Research in the Dry Areas (ICARDA) in 2007 and spent seven years disseminating conservation agriculture information in Iraq and Syria on a project funded by the Australian Centre for International Agricultural Research (ACIAR).

"Trial establishment, measurements of soil, crop, weed and pest parameters, and data analysis were major components of this work. I also gained valuable skills in coordinating farmer surveys investigating zero-tillage adoption in Syria and contributed to grower workshops to improve adoption and development of local zero-tillage seeders."

He won an ACIAR/John Allwright Fellowship, funded by AusAID, to undertake his PhD on the interaction between pre-emergent herbicides and crop residues in no-till farming systems in Western Australia. He moved to Australia in 2014, completing the PhD in 2018, and started work on the GRDC-supported postdoctoral project in 2019.

BENCHMARK GROWER SURVEY

Dr Khalil's work involves several facets but it was started with a foundational survey with cooperating AHRI farmers across the WA wheatbelt to compare paddock management by growers using pasture phases, with growers who operated with little rotational diversity. Seedbank evaluation on these selected farms helped to quantify the effectiveness of management methods using disruptive pasture phases in achieving low weed seedbanks.

Directed by the survey, a serradella and weed control focus site was established at the UWA farm at Pingelly to evaluate weed control management options – singularly and in combinations – in reducing weed seedbanks in serradella phases.

"The French serradella variety Cadiz⦇ was selected as the pasture species because, in addition to its ability to fix nitrogen, it has been shown to reduce root lesion nematode in subsequent cereal crops, as well as other soil-borne crop pathogens. It is low-cost to establish and specifically developed for use in phases to be directly harvested for seed, grazed or used as silage," Dr Khalil says.

Siting the trial at the UWA farm meant animals could graze the trials. Two additional sites were established at Bolgart and Brookton to focus on the impact of serradella phases in minimising weed seed-set in crop rotations, primarily focused on ryegrass. The serradella pasture phases where one, two or three years in duration.

"From the university farm site, we concluded that although single weed management tactics were not effective in providing weed number reduction early in the growing season, some of them – weed wiping, spray-topping, mowing and spray-topping, hay/silage production, green manuring, brown manuring – applied at full canopy stage were very effective in reducing weed seed production," Dr Khalil says.

Analyses to determine effects on disease levels and the economics of the rotations will be carried out at the end of the rotations.

Dr Khalil is keen to pursue his interest in developing robust farming systems for Australia. He is especially interested in farming systems and reintegrating pastures into Australian cropping rotations. □

GRDC Code UWA1811-003RTX

More information: Dr Yaseen Khalil, 0449 880 461, yaseen.khalil@uwa.edu.au

New insights into link between soil strength and soil water

Australian soils are ancient and diverse, and they vary in their ability to support different forms of land use. Management and remediation of these soils requires in-depth knowledge of a soil's chemical, physical and biological properties

■ To improve our understanding of the nature of physical constraints in sandy cropping soils, Dr Rodrigo da Silva has brought soil physics and nutrition experience from South and North America to work on a GRDC-supported postdoctoral project.

"Besides the inherently low rainfall in many Australian cropping areas, grain yield is often limited further by various soil constraints, such as lack of nutrients, excessive sodicity, acidity or alkalinity, as well as physical barriers stopping root penetration," Dr da Silva says.

"Therefore, being a soil scientist working closely with the grains industry is very rewarding as the findings of our research to overcome these constraints can impact the way growers manage crops."

Before moving to Australia in 2013, Dr da Silva completed his postgraduate training in soil science and plant nutrition at the University of São Paulo in Brazil. His research experiments and analyses were carried out in collaboration with the Mato Grosso Research Foundation and Centre for Nuclear Energy in Agriculture, together with collaborators at the Argonne National Laboratory in Illinois and Kansas State University in the US, where he spent a one-year doctorate "sandwich" program. Prior to this, he obtained his agronomic engineering degree from the São Paulo State University.

"Prior to joining the GRDC-invested sandy soils project at CSIRO Agriculture and Food, I served as a member of an interdisciplinary research team at the University of Adelaide. We conducted experiments to develop more effective fertiliser formulations and minimise potential environmental risks," he says.

SANDY SOIL CONSTRAINTS

Dr da Silva is examining the properties of sandy soils found across the southern grains region. Subsurface physical constraints can occur in these soils due to high bulk density induced by compaction, chemical reactions that cause cementation, or from hard-setting processes that change with soil moisture content.

He says it is important to understand the cause of high soil strength because this could determine the best amelioration method and longevity of benefits.

"We found that subsurface hard-setting was common to all four research sites and the hard sandy soil layers usually started at about 30 centimetres depth."

The research demonstrated that as these deeper layers dry, their soil strength increases dramatically, so that small changes in moisture can have a big impact on the severity of the physical constraint.

"Despite much discussion with the wider project team, and contrary to our original hypothesis, we have not found cementing behaviour in the sands studied at the four sites."

Cemented sands should retain their shape/structure when immersed in water, and this was not the case with the hard subsurface layers at the four sites. Traffic-induced compaction was also ruled out as the layers above and below the hardened layer had similar soil bulk densities.

Testing is expanding to other experimental sites in 2021 and 2022.

"Now that we are beginning to understand the relationship between soil strength and soil water in the hard-setting layers, we are seeking diagnostic methods that would allow growers to identify these layers more easily. Additional analyses will be performed to achieve this objective, such as using infrared spectroscopy. This will be important in targeting deep-ripping practices to ensure that yield improvements can be achieved and maintained as long as possible."

Dr da Silva's goal is to continue research with a strong scientific basis, but at the same time with practical benefits to growers and the grains industry. □

GRDC Codes CSP1606-008RMX

More information: Dr Rodrigo da Silva, 0421 092 680, rodrigo.dasilva@csiro.au

Photo: Bill Davoren, CSIRO

A sandy soil profile where the hard layer is present at approximately 50 centimetres' depth. Research indicates these layers are not caused by compaction but appear to occur naturally due to hard-setting processes.

Photo: courtesy Rodrigo da Silva

Dr Rodrigo da Silva has brought training and experience from South and North America in soil physics and nutrition to investigate sandy soil constraints in cropping systems in southern Australia.

Horsham – an industry capacity-building incubator

Major investments by GRDC with specialist research providers including Agriculture Victoria are important capacity-building vehicles that focus on priority grains industry issues

■ Building industry-wide research and innovation capability by training the future grains knowledge workforce is one of the core objectives of the Victorian Grains Innovation Partnership – an eight-year, $88 million co-investment by GRDC and Agriculture Victoria. Located at a world-leading research precinct at Horsham, in the heart of the Victorian grainbelt, six PhD research fellowship recipients are studying priority industry issues. The students are part of the Centre for Agricultural Innovation, a joint initiative between Agriculture Victoria and the University of Melbourne.

PULSE ROOT ARCHITECTURE

Roots are a critical, yet under-studied, component of pulse productivity and **Spencer Fan** is developing assays to assess variability in pulse root traits. Significant variation has been found and he is now keen to investigate root plasticity – the ability of the root to change its growth pattern in a range of soils in search of nutrients or water. The results of his PhD will give insights into the types of root architecture that are most suited to Victoria's various cropping regions.

Mr Fan's interest in plant science was sparked by his undergraduate degree in science at the University of Melbourne.

"Towards the end of my degree, I was fortunate to undertake an internship with the Agriculture Victoria pulse breeding group at Horsham," he says. "The positive experience from the internship led me to complete a Master of Agricultural Science, completing a major research project with Agriculture Victoria that investigated how changes in above ground field pea architecture influences yield."

Mr Fan was introduced to his PhD supervisors, Professor Roger Armstrong and Dr Garry Rosewarne, during this research project, which ultimately led him to pursue a PhD focusing on root architecture in pulses.

MUNGBEANS FOR SOUTH-EASTERN AUSTRALIA

Sachesh Silwal brings years of experience, working on plant adaptation, to his study of mungbean adaptation for south-eastern Australia.

"I was born in Nepal and completed my degree in plant breeding at Tribhuvan University, Nepal, in 2005, before moving to Australia in 2013," he says. "I completed a Master of Applied Science (Research) at Central Queensland University in 2017.

"Over the past 10 years or more I worked in plant breeding, agronomy and plant physiology research with various crops under different agro-ecologies, including dryland, high mountain, temperate and tropical, within commercial and subsistence farming."

Mr Silwal is now applying his experience to evaluating the agronomic suitability of mungbeans to southern Australia by exploring crop phenology, temperature responses, water and nitrogen dynamics, under the guidance of supervisors Dr James Nuttall, Dr Sally Norton, Audrey Delahunty and Associate Professor Joe Panozzo.

ON-FARM STORAGE TO OPTIMISE LENTIL QUALITY

Bhawana Bhattarai is investigating the effects of storage conditions on lentil quality initially using laboratory experiments.

Using data collected to build biophysical models that explain changes in lentil quality during storage, Ms Bhattarai is then transferring this knowledge to larger cone-type storage facilities used by growers. This study is important to help growers monitor and optimise on-farm storage conditions to maintain grain quality and maximise returns.

All photos: DEDJTR

Spencer Fan examining root system architecture, including rooting depth of pulses in deep cores.

Sachesh Silwal is focusing on mungbean adaptation in southern Australia for his PhD study.

Bhawana Bhattarai collecting digital images of stored lentils to monitor colour changes.

Ms Bhattarai completed a Bachelor of Science in Agriculture at Tribhuvan University, Nepal, followed by a Master of Biotechnology and Bioinformatics in 2019 at La Trobe University.

"I believe that agricultural systems can feed the world, which is becoming more populated, but they need to be productive, efficient and profitable," she says. "Grain storage on-farm plays an important role in the quality and price of the grain, and I'm keen to investigate best practices that growers can implement."

Ms Bhattarai's PhD study is being supervised by Associate Professor Glenn Fitzgerald, Dr Cassandra Walker, Dr James Nuttall, Dr Kate Howell and Ashley Wallace.

SENSOR TECHNOLOGIES TO DETERMINE PULSE QUALITY

Different abiotic and biotic stresses – including heat, drought and disease – impact grain development and quality in pulses. **Danielle Tang** is investigating how sensor technologies can be used to assess lentil and faba bean crops before harvest and the impact of various stress factors on grain quality.

"This will be a significant gain for growers as it will enable segregation of grain during harvest with the aim of capturing premiums to achieve grade-one pulses," she says.

For example, a small, badly diseased section of a paddock might lead to a downgrade in quality if the paddock was harvested as a whole. But by segregating the diseased area, the rest of the paddock could attract a price premium.

Ms Tang completed her Bachelor of Agriculture at the University of Melbourne in 2019. "I'm interested in seeing how agriculture can be made a more sustainable industry with the use of advanced sensor technologies," she says.

"In my honours project, I explored machine learning techniques and how, using sensor technologies, these can be applied to develop models to predict wine quality. I will now apply these skills in pulses in my PhD project."

Ms Tang's study is being supervised by Associate Professor Glenn Fitzgerald, Dr Cassandra Walker, Dr Dorin Gupta, Dr James Nuttall and Audrey Delahunty.

SOIL CONSTRAINTS

Life spent on **Keshia Savage**'s grandfather's farm in the Western District of Victoria gave her a passion for agriculture, leading to study at Longerenong Agricultural College and then a technical role in pulse agronomy at Agriculture Victoria.

"This research experience encouraged me to obtain a Bachelor of Agricultural Science from La Trobe University. Pursuing a PhD in this field is not only a logical step in my education but a chance for me to contribute to an industry supporting local growers and our global food supply," Ms Savage says.

"For my PhD, I'm looking to understand the mechanisms by which multiple soil constraints affect annual dryland crops to help identify and develop more effective management strategies that improve crop production."

Soils can vary enormously within a paddock and it's important to understand how various constraints interact and what practices can help overcome those.

Ms Savage's PhD study is being supervised by Professor Roger Armstrong and Dr Clayton Butterly.

Her research project involves controlled-environment and field research, and will use a range of soil and crop sensing technologies to examine the relationship between soil physico-chemical properties and the response of grain crops to different management interventions on a three-dimensional spatial scale.

NOVEL SOIL MANAGEMENT TO BOOST RAINFALL USE

Water deficits are the principal limitation to grains productivity and profitability in Australian temperate cropping systems. **Amit Adhikari** is developing and assessing the potential of new management strategies to improve the capture and utilisation of rainfall by grain crops in future climates.

"Rainfall patterns are variable and changing, and this gives us new opportunities for water conservation options. Using a specially constructed rainfall simulator in the field, my experiments aim to help develop practices that increase crop water use with novel soil engineering techniques such as polymers and stubble management," Mr Adhikari says.

Mr Adhikari completed his bachelor and Master of Science in Agriculture at Tribhuvan University in Nepal. He has more than five years' experience working in crop and soil science.

He moved to Australia in 2017 and worked in agribusiness for two years before commencing his PhD in October 2020. His studies are being supervised by Professor Roger Armstrong, Dr Garry O'Leary and Dr Clayton Butterly. □

GRDC Code DJP1910-006BLX

More information: Dr Jennifer Sexton, 0438 981 294, jennifer.sexton@agriculture.vic.gov.au

Danielle Tang scanning lentil grain using a near-infrared spectrometer.

Keshia Savage measuring leaf transpiration on different wheat germplasm.

Amit Adhikari examining the effect of different soil polymers on water infiltration.

Mitch Buster is part of a large GRDC–NSW Department of Primary Industries capacity-building project. He is studying the interaction of root architecture with water use and Fusarium crown rot in high-value cereals with the aim of improving productivity.

Multiple skills for challenging environments

Photo: Hayley Wilson

Traditional crop science skills are being combined with the latest sensor technology to support crop management decisions

Adaptability to water scarcity and the ability to tolerate or resist diseases are fundamental crop production features for challenging environments.

For Mitch Buster, these are key drivers underpinning his grains industry research.

"Raised on an irrigation property west of Bourke, NSW, I have always had a keen interest in Australian agriculture. When an opportunity arose to be involved in the future of the grains industry, it appeared to be a good fit and an exciting opportunity," Mr Buster says.

Mr Buster has an honours degree in rural science from University of New England in 2019, exploring the effects of banded phosphorus in tropical and subtropical pasture systems, particularly assessing the impacts on root system architecture. He is well-equipped to tackle a PhD combining agronomy, pathology and physiology.

Mr Buster's postgraduate study is part of a GRDC-invested capacity-building project for the northern region. It is being supervised by Dr Steven Simpfendorfer (NSW Department of Primary Industries) and Dr Richard Flavel (University of New England).

MULTIDISCIPLINARY APPROACH

"My PhD study is taking a multidisciplinary approach exploring root architecture to improve nitrogen and Fusarium crown rot (FCR) management in high-value winter cereal crops," he says.

"In particular I will look to understand the effects of crown rot infection on the physiology of nitrogen movement, nitrogen use efficiency and grain quality in Australian Prime Hard (APH) and durum wheat.

"I will then investigate whether there are genetic differences in root architecture of commercially available APH wheat and durum varieties that can influence the depth and timing of nitrogen uptake and soil water use, and if this can be exploited to improve fertiliser use efficiency."

Mr Buster is also exploring a range of novel technologies to more accurately determine soil water, tissue nitrogen and Fusarium disease levels at key growth stages during the season to guide further management decisions.

"I am especially interested in exploring broadacre detection of FCR using remote sensing, as this could significantly aid the timeliness and accuracy of decisions."

Results from glasshouse trials in 2020 have confirmed that infection with FCR reduced grain yield by 9.5 per cent and water use by 7.5 per cent compared with non-infected plants. This is the first confirmation that FCR reduces water use.

"Using a drone fitted with a radiometric thermal camera, I have identified FCR-infected plots at stages before visual symptoms – basal browning – were expressed. This occurred with temperature increases of 0.9°C compared to non-infected treatments."

Increased canopy temperature is caused by plants being unable to transpire as efficiently as non-infected plants. This is likely due to the fungus colonising the plants' vascular tissue and compromising plant function.

"This fundamental scientific finding using cutting-edge technology could provide a new way to detect FCR tolerance and screen varieties for this."

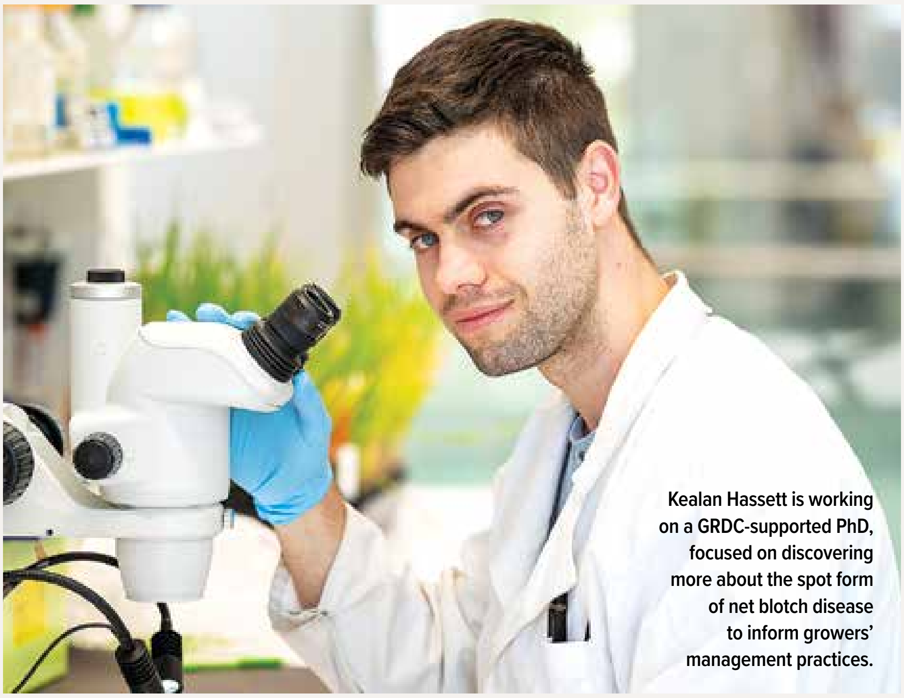
The ability to detect FCR spatially across fields may allow site-specific management of FCR infection. Coupling this information with further study of potential genetic differences in root architecture, depth and timing of nitrogen uptake and soil water use could improve fertiliser use efficiency and achieve protein targets for premium cereal crops.

Mr Buster enjoys the applied aspect of his work and is keen to work with growers and consultants on industry priorities in the future. □

GRDC Code BLG309

More information: Mitch Buster, 0428 306 914, mitch.buster@dpi.nsw.gov.au

Photo: Evan Collis



Kealan Hassett is working on a GRDC-supported PhD, focused on discovering more about the spot form of net blotch disease to inform growers' management practices.

Photo: Simon Ellwood, CCDM

Spot form of net blotch is a major foliar disease of barley worldwide, caused by the fungus *Pyrenophora teres* f. *maculata* (*Ptm*).

Plant-pathogen intrigue drives research interest

Diseases that cause significant losses to the grains industry require constant review and upgrade of scientific knowledge to inform control measures

■ A keen interest in plant-bacteria interactions in the rhizosphere and the role of plasmids was kindled in Kealan Hassett when completing his undergraduate studies in molecular genetics and biotechnology at Western Australia's Curtin University.

Although he was city born and bred, Mr Hassett's interest in plants had been fostered by his horticulturalist father. He is now set to contribute to the scientific understanding of a significant Australian barley disease.

He became interested in his area of study after attending an honours expo in the final year of his undergraduate degree. The expo presented the opportunity to undertake a proteomics project on the "weird and wonderful" world of plant-pathogen interactions with the university's Centre for Crop and Disease Management (CCDM).

"After completing my honours in 2018 and publishing the results in late 2019, I volunteered as a research assistant within the CCDM labs. In the meantime, another project opportunity arose in late 2019. This new project was in the form of a GRDC-supported PhD looking at the population structure and virulence of spot form of net blotch of barley within Australia, which I commenced in early 2020.

"This project was more in line with my undergraduate degree and was of interest to me as I have previously enjoyed learning about population genetics."

Mr Hassett's PhD studies are being supervised by Dr Jordi Muria-Gonzalez and Dr Simon Ellwood.

ABOUT SPOT FORM OF NET BLOTCH

Spot form of net blotch is a major foliar disease of barley worldwide. It is caused by the fungus *Pyrenophora teres* f. *maculata* (*Ptm*). Knowledge of the pathogen's genetic diversity and population structure is critical to better understand the disease's evolutionary capacity and the development of sustainable disease management strategies.

"For my PhD project, we assembled a collection of 269 *Ptm* isolates together with 10 other *P. teres* spp. isolates collected from across Australia. Modern genotype-by-sequencing markers were used to analyse the level of genetic diversity of the disease across the country. More detailed analyses were also conducted in WA between agro-ecological zones, fields and host varieties," Mr Hassett says.

"Preliminary results revealed *Ptm* is genetically diverse throughout Australia and displays little population structure, meaning the disease doesn't form any genetically distinct groups at the state, agro-ecological zone, or field levels."

As commercial barley lines have low levels of resistance to spot form of net blotch, it appears this has enabled unconstrained proliferation of the fungus with movement across Australia, likely aided by people and machinery agricultural activities.

"The results provide a foundation for improved spot form of net blotch disease management in Australia and suggest a nationally coordinated program will be prudent for effective disease control," Mr Hassett says.

"However, developing an effective strategy is challenging, as populations with high genetic variability have greater potential for overcoming chemical and genetic controls."

The next step for his project is to look for disease variability on different varieties of barley lines (pathotyping).

"From there, I will look for genetic regions associated with the observed virulence differences in a genome-wide association study using both the genotyping data from the first part of the study and the pathotyping data from the second part of the study."

Mr Hassett is 18 months into his study and is excited about the discovery aspect of the work he is doing for the grains industry. Once completed, he would like to continue in plant pathogen and cereal crop research. □

GRDC Code CUR2002-002RSX

More information: Kealan Hassett, 0484 840 030, kealan1996@gmail.com

Role models nurture plant pathology skills

Economically significant diseases require management practices informed by state-of-the-art skills and training

Photo: Evan Collis

Virginia Wainaina Mwape has developed genetic and pathology skills to support improved management of Sclerotinia stem rot through a GRDC-supported capacity-building project at Curtin Centre for Crop and Disease Management at Curtin University.

■ Research aimed at helping breeders develop locally adapted chickpea cultivars that are more resistant to *Sclerotinia sclerotiorum* is at the forefront of Virginia Wainaina Mwape's studies at the Centre for Crop and Disease Management (CCDM) at Curtin University in Perth.

Through a GRDC-invested capacity-building project, Mrs Mwape is investigating the level of resistance to Sclerotinia stem rot in current cultivars and wild germplasm. She is hoping that combining resistance identified in wild chickpea accessions into cultivated chickpeas will ultimately lead to varieties with enhanced Sclerotinia resistance and higher, more reliable yields. This objective is also part of her next career goal as a postdoctoral plant pathologist.

Mrs Mwape hails from Kenya, where she was raised on her parents' small farm that specialised in fruit production – mainly avocados – for export, and maize and pulses for local consumption. It was this farming background that influenced her to pursue agriculture as a profession, beginning by obtaining a bachelor's degree in general agriculture from Egerton University, Kenya, in 2004.

She initially came to Australia for a short course in dryland farming in 2013-14 at the University of Queensland, but the Australian scientific leadership and role models she worked with soon drew her back.

"I was inspired by the high level of agriculture research and the effort and commitment of the Australian research scientists," Mrs Mwape says. "In 2015, I returned to Australia to study a master's in dryland agriculture at Curtin.

"In particular, I was motivated by researchers from the CCDM, where I undertook my master's thesis project, which focused on fungicide resistance."

In 2017, she committed further to her training and enrolled for a higher degree in research, supervised by CCDM theme leader Dr Lars Kamphuis, to give back to the Australian community by joining this group of committed crop disease researchers.

Her PhD has been supported by GRDC, Curtin Postgraduate Research Training Scholarship and Research Stipend Scholarship and a top-up scholarship from CSIRO. Her studies are being supervised by Dr Kamphuis, as well as Dr Mark Derbyshire and Dr Toby Newman of the CCDM theme that focuses on canola and pulse diseases.

"My PhD research aimed to explore the physiological and genetic resistance of a collection of wild chickpea and elite cultivated chickpea varieties to Sclerotinia stem rot caused by the pathogen *Sclerotinia sclerotiorum*," Mrs Mwape says.

"My research also aimed to characterise the molecular mechanisms used by this pathogen to infect chickpeas and the plant's molecular defence responses when invaded by *Sclerotinia*."

CCDM director Professor Mark Gibberd says one of the CCDM's core objectives is the development of new research capability. "Virginia has developed a remarkable skill set while also delivering outputs which will contribute to the future viability of chickpea production in Australia," he says.

"The co-support of Curtin, GRDC, CSIRO and the collaborative involvement of the University of Adelaide has generated a fantastic research training opportunity. We all wish Virginia the best for a bright career ahead." □

Photo: Yuphin Khentry, CCDM

Virginia Wainaina Mwape inspects a F_7 recombinant inbred line (RIL) population derived from cultivars PBA HatTrick⊕ and Kyabra⊕, as well as the parental material. The population was evaluated for its response to the pathogen *Sclerotinia sclerotiorum*, the causal agent of Sclerotinia stem rot in chickpeas, canola and other pulses. This project was conducted in collaboration with Professor Diane Mather's team at the University of Adelaide's School of Agriculture, Food and Wine.

GRDC Codes CUR1406-001RTX, CUR1403-002BLX

More information: Virginia Wainaina Mwape, 0469 841 345, virginia.wainaina@postgrad.curtin.edu.au

Capacity building to support 'next-gen' wheat

100-day wheats are being evaluated through a GRDC capacity-building project in collaboration with an Australian breeding company

KEY POINTS

- Cropping in a changing climate requires new tools
- 100-day wheats may give additional time at the start of the year for weed control
- 100-day wheats may allow delayed sowing to reduce frost risk

New tools are required by farmers to deal with changing climates. Having grown up on a Merino stud and worked in the cotton industry, Tim Green is well aware of this need.

"Climate change is going to be the number one issue facing Australian agriculture in the coming years, and without proactive research into mitigating the risks associated with this, we're going to fall behind global food demands," Mr Green says.

After completing a degree in science at Charles Sturt University and majoring in plant science, microbiology and immunology (and then honours in wheat pathology at the Australian National University), he gained experience as a cotton pathologist. But now his focus is on a new challenge – a 100-day wheat adapted to the changing Australian climate.

"After several conversations over a year ago with Dr Greg Rebetzke from CSIRO, who has been developing these shorter lines, I saw this research area as a fantastic opportunity for me to not only return to the wheat industry but also to study something unique and potentially pivotal for the industry," Mr Green says.

"A 100-day wheat would be suited to future conditions in southern Australia, capable of being sown mid-winter then progressing through its life cycle in a far quicker time than current varieties, and yet still producing near-equivalent yields.

"Benefits include reduced risk in changing climates, for example enabling late sowing breaks and avoiding frost, potential for double-knocking herbicide-resistant weeds, and greater flexibility in varietal adaptation with increasingly larger sowing programs."

With these benefits, it is expected that later-sowing varietal options with cold tolerance could contribute to greater profitability.

"I am not aiming to breed shorter-duration wheats *per se* in this project, but rather to conduct preliminary investigation into identifying traits essential for improving the performance and reliability of a wheat variety like this."

Mr Green's study is being supervised by Dr Felicity Harris (NSW Department of Primary Industries), Dr Rebetzke, Dr Daniel Mullan (InterGrain) and Dr Sergio Moroni and Professor Jim Pratley (both Charles Sturt University). It is supported by a GRDC Research Scholarship and an Australian Government Research Training Program award as delivered by Charles Sturt University.

InterGrain is also supporting Mr Green spending time with the company's breeders in Western Australia, illustrating the importance of collaborative capacity building within Australian grain businesses.

Experiments have been sown in Wagga Wagga in collaboration with Dr Harris and NSW DPI, and high early vigour lines have been provided by Dr Rebetzke and Dr Mullan. These experiments will investigate how new breeding lines perform against current varieties when sown late, as well as allowing for important characteristics to be identified. The results from the experiments will inform the direction of the rest of the project in terms of identifying the specific lines or traits that will be studied in greater depth.

The experiments will include unreleased high early vigour lines, several Chinese accessions, the variety Sunset – a historic variety bred by William Farrer – and Apogee, an extremely short life cycle variety developed by NASA and the Utah Agricultural Experiment Station for use on space stations. A component of the experiments will be to evaluate some of the extremely diverse characteristics of fast-cycling wheats.

Mr Green is open to change, as reflected by his career so far: "Every year since completing my undergraduate degree has found me in a different or changed role within the research community. I'm cautious about crystal balling where I'll end up, but for now am thrilled to enjoy the experience of my PhD and the skills, learnings and people I'm meeting along the way. I'll worry about the future when it arrives!" □

GRDC Code UCS2105-002RSX

More information: Tim Green, 0477 497 114, tigreen@csu.edu.au, @TGreen_001

Photo: Sergio Moroni, Charles Sturt University

Part of Tim Green's PhD studies at Charles Sturt University will involve evaluating high early vigour wheat lines as a trait to improve productivity under changing climatic conditions.

Problem solver gets to grips with soil amelioration

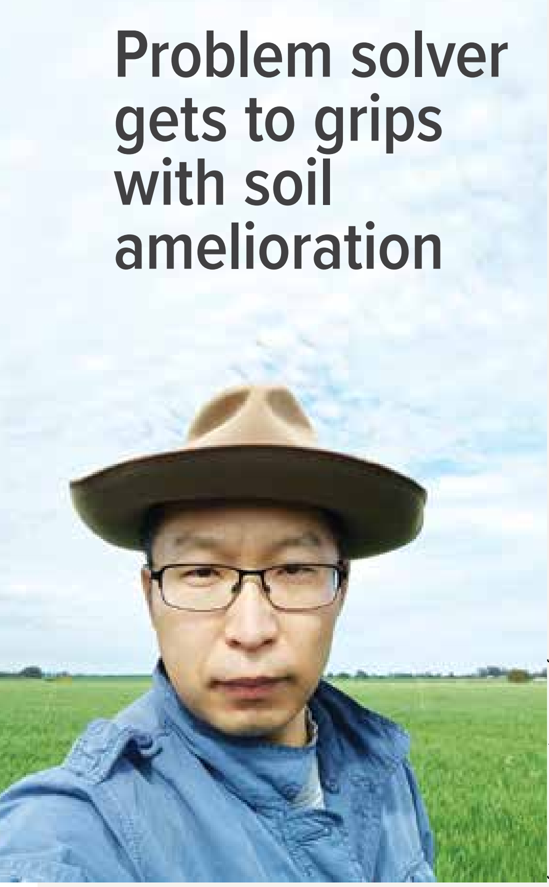


Photo: courtesy Dr Jian Jin, La Trobe University

Dr Jian Jin from La Trobe University is unpicking the crop and soil responses to soil amelioration as part of a GRDC-invested capacity-building project.

Major investments by GRDC addressing significant crop production issues also provide opportunities for scientific capacity building for the grains industry

■ Dr Jian Jin is a problem solver who is particularly drawn to understanding mechanisms in new farming systems that have potential to improve grain production.

His GRDC-supported postdoctoral research began in 2016 as part of a project to understand the amelioration processes for subsoil application of organic and other amendments in the southern region.

The research was supervised by Agriculture Victoria researcher Professor Roger Armstrong at Horsham. Dr Jin's role was to show how subsoil amelioration treatments were able to deliver changes in soil physical properties, root growth, canopy development and crop yield.

Equipped with a degree in agronomy from Northeast Agricultural University, China, Dr Jin completed a PhD in 2016 at La Trobe University, studying soil carbon and nutrient cycling, plant nutrition, crop physiology and agronomy.

"I am keen to conduct research that improves understanding of the nature of practical problems and provides integrated solutions in the fields of soil management, crop physiology and agronomy," he says.

DISSECTING RESPONSES TO AMELIORATION

Dr Jin took crop and soil measurements on four selected treatments at two of the Victorian experimental sites where dense sodic clay subsoils are a major constraint to crops: Tatyoon in the high-rainfall zone, and Kiata in the medium-rainfall zone.

The objective was to understand how subsoil amelioration treatments deliver changes in soil properties, root exploration, crop water use, the development of the crop canopy and biomass, and grain yield, under different rainfall regimes.

The four treatments in Dr Jin's study were only applied at the start of the experiments in 2018, and included (1) an unamended control, (2) 10 tonnes per hectare of gypsum placed at 20 to 30 centimetre depth, (3) chicken manure added to topsoil, and (4) chicken manure added at 20 to 30cm depth. Chicken manure pellets were applied at 20t/ha at the Tatyoon site and 15t/ha at the drier Kiata site.

Both sites experienced two dry seasons with dry springs followed by a wetter year. At Tatyoon, the annual rainfall was 436, 442 and 557 millimetres for 2018, 2019 and 2020, respectively. At Kiata, the corresponding annual rainfall was 249, 225 and 430mm.

At the Tatyoon site in 2018, the manure subsoil application resulted in 8.1t/ha of wheat, 23 per cent above the control yield of 6.6t/ha. However, in 2019 and 2020 when barley and faba beans were grown, the mean yield increases with the subsoil manure of 0.3 and 0.2t/ha, respectively, were not statistically different to the control. Yields in the surrounding paddock were similar to those in the control treatment.

At the drier Kiata site, there were no significant increases in grain yield compared with the control in 2018 and 2019, in part reflecting the dry seasonal conditions (decile 1 to 3).

Dr Jin says the deep banding of manure at the wetter Tatyoon site had positive effects on the soil, including an increase in rainfall infiltration into the subsoil. This could potentially minimise the development of perched water tables (causing waterlogging), which are quite common on sodic clay subsoils in this region.

Root growth increased in the soil around the subsoil manure, which was associated with increased crop water use. Consistent increases in crop canopy photosynthesis, transpiration efficiency and green leaf duration were observed with the manure amendment.

> "I AM KEEN TO CONDUCT RESEARCH THAT IMPROVES UNDERSTANDING OF THE NATURE OF PRACTICAL PROBLEMS AND PROVIDES INTEGRATED SOLUTIONS IN THE FIELDS OF SOIL MANAGEMENT, CROP PHYSIOLOGY AND AGRONOMY." – DR JIAN JIN

However, these benefits failed to deliver crop yield increases in the second and third years of the trial.

"We think this may be due to the subsoil constraints at Tatyoon not being severe enough to limit crop yields in these years when the crop was less reliant on subsoil moisture in spring," Dr Jin says.

Although opportunities to meet face to face were restricted by COVID-19 in 2020, Dr Jin has benefited greatly from Professor Armstrong's supervision and interaction with the wider research team across four states.

"Designing resilient cropping systems and understanding the drivers of these systems is going to be imperative for growers to maintain profitability as we experience climate change and I am keen to focus my future research on these issues for the benefit of the Australian industry." □

GRDC Code ULA1806-001RTX

More information: Dr Jian Jin, 0406 091 227, j.jin@latrobe.edu.au

Wheat adaptation puzzle solutions

With his enquiring mind and penchant for puzzles, David Cann is using his problem-solving skills to solve future wheat adaptation challenges

■ From David Cann's perspective as a researcher, understanding cropping and the Australian grains industry is like a complicated board game or puzzle. Crop management, breeding, biotic and abiotic stresses, whole-farm factors and market influences are just some of the components that need to come together to produce a profitable crop and a successful industry.

"I love the variety that comes with being a grains researcher and the problem-solving skills it requires," Mr Cann says.

He applied his problem-solving skills to a wheat adaptation problem through a GRDC capacity-building project and has completed a PhD at La Trobe University. Professor James Hunt (La Trobe University), Dr Felicity Harris (NSW Department of Primary Industries), Dr Kenton Porker (Field Applied Research Australia) and Dr Allan Rattey (InterGrain) supervised his studies.

His research project, 'Adaptation of fast winter wheat genotypes to the Mediterranean semi-arid cropping regions of southern Australia', focused on breeding and evaluating new winter wheat genotypes for growers in southern Australia.

WHEAT ADAPTATION PUZZLE

Early sowing of wheat can increase yield despite recent declines in growing season rainfall. However, this requires cultivars with suitable development patterns to ensure that flowering occurs during the optimal flowering period (OFP), during which the risks of flowering too early (low radiation, frost) and flowering too late (heat and drought) are balanced.

Winter wheat, which must experience sufficiently cool temperatures before beginning reproductive growth, has a stable flowering time across a range of sowing dates, making it suited to early sowing.

"My project aims to identify the traits required for high yield in winter wheat and understand how they can be incorporated into breeding programs," Mr Cann says.

"As part of my PhD, I planted and assessed over 500 early generation spaced single winter wheat plants in a field experiment in north-western Victoria. Research indicated that selecting plants for high harvest index (grain yield as a proportion of biomass) resulted in higher-yielding progeny, compared to the 'no-selection' control.

"Early generation selection for harvest index could therefore be a useful tool for breeders to improve yield gain and accelerate the release of winter wheat cultivars to Australian growers."

Field experiments were also conducted at eight sites with different OFPs across eastern South Australia, northern Victoria and southern NSW, using winter wheat lines with different development patterns. Results indicated that lines with a 'very quick' and 'quick' phenology – equivalent to or quicker in phenology than Illabo⟨D⟩ and Longsword⟨D⟩ – showed good yield adaptation across environments

"These results are promising for Australian wheat breeders and growers, indicating that new releases of winter wheat will be suited to low and medium-rainfall zones right across southern Australia.

"The results also indicate that very quick winter wheat – which has a development pattern faster than any current commercial cultivars – has the right phenology to achieve high yields from early sowing dates in environments with an early OFP."

Mr Cann is concerned about the impacts of climate change in agriculture. "I find being able to work with growers to adapt management practices or with breeders to develop new cultivars in response to climatic changes really motivating," he says.

He came to agriculture through studying international development at La Trobe University. "I am very interested in the role that grain growers – both in Australia and in other regions – have in driving food security and feeding growing populations across the world.

"I also really enjoy learning new languages – so I guess I see myself working overseas at some point in the future, hopefully for a research non-government organisation. In the meantime, though, I feel like I have much more learning ahead of me, in both the crop agronomy and breeding domains." □

GRDC Code ULA1802-002RSX

More information: David Cann, 0433 594 093, d.cann@latrobe.edu.au, @the_ag_lab, @agronomeiste

Photo: Professor James Hunt, La Trobe University

David Cann of La Trobe University testing adaptation of different wheat phenology groups (very quick, quick and mid) of winter wheat across flowering time environments as part of a GRDC-supported capacity building project. This was the Marrar field site in NSW managed by Dr Felicity Harris, NSW DPI.

Photo: David Cann, La Trobe University

Recombinant inbred winter lines varying in development speed derived from a spring/mid long cross (Mace⟨D⟩ / Gauntlet⟨D⟩).

Discovery opens new front on charcoal rot research

An intriguing industry problem to solve is key to capacity-building projects for young scientists

■ Charcoal rot is a significant disease of sorghum as well as most other major summer crops, including mungbeans, maize and soybeans. It is challenging to manage due to the lack of effective cultural, agronomic and chemical management options. But Dr Barsha Poudel might have discovered new knowledge to better inform its management.

Originally from Nepal, where she attained a bachelor's in biotechnology from Kathmandu University, Dr Poudel has added a master's in bioinformatics from Wageningen University in the Netherlands to a PhD from the University of Southern Queensland. She brings a special set of skills to this industry issue.

Photo: USQ Photography

Dr Barsha Poudel from the University of Southern Queensland has discovered new knowledge to inform the management of charcoal rot in summer crops as part of a GRDC-supported capacity-building project.

Photo: Dr Niloofar Vaghefi, USQ

Charcoal rot symptoms caused by *Macrophomina* observed in sorghum stalk.

"My PhD project investigated the genetic and pathogenic characterisation of *Pyrenophora teres* and their hybrids – the causal agent of net blotch – on barley," Dr Poudel says.

Her current position at the University of Southern Queensland (USQ) as a GRDC-supported postdoctoral researcher is supervised by Dr Niloofar Vaghefi.

The project here focuses on characterising the genetic variability and structure of what is thought to be the major cause of charcoal rot, the fungus *Macrophomina phaseolina*.

"The project was started by Dr Neeraj Purushotham at USQ, then carried out by myself since early 2020," Dr Poudel says.

"I collected samples from sorghum paddocks in Queensland and NSW, and have been analysing their diversity using genotyping-by-sequencing approaches. The work aligns very well with my PhD work (on net blotch)."

AN ASSOCIATED ROT

Dr Poudel's current work is focused on understanding two aspects of charcoal rot disease on sorghum. The first is to characterise the genetic diversity and population structure of charcoal rot pathogens in sorghum paddocks in the northern grains region to increase this knowledge base.

"This is important because to develop effective strategies for charcoal rot management, we need to first develop a good understanding of its biology and epidemiology," she says.

The second aspect is to understand the impact of moisture stress and different levels of *Macrophomina* inoculum in soil on charcoal rot severity in sorghum plants. The commonly used symptom-based disease assessment method takes into consideration lesion length, which may not be adequate to reflect charcoal rot severity in sorghum as it is not a true reflection of the extent of tissue colonisation by the pathogen.

"This has given me the opportunity to use a DNA-based pathogen quantification tool (PREDICTA® B, provided by the South Australian Research and Development Institute) to quantify pathogen biomass within sorghum plants."

It was through Dr Poudel's investigative approach that a discovery was made.

"A novel fungal species was detected in sorghum paddocks in the northern grains region. Previously, only *Macrophomina phaseolina* was considered as the cause of charcoal rot in sorghum in Australia, but our research revealed a new *Macrophomina* species, named as *Macrophomina tecta*.

"Our study detected long-distance dispersal of this pathogen among Queensland and NSW sorghum paddocks. This suggests that seed-borne inoculum may have a more important role in pathogen dissemination than previously assumed.

"The moisture stress work confirmed that moisture stress has a significant impact on charcoal rot development on sorghum. Under moisture stress, infections in sorghum were observed even at low pathogen inoculum levels in soil."

IMPLICATIONS

Dr Poudel has found the DNA test (PREDICTA® B) has the potential to provide an accurate and reliable method to estimate charcoal rot severity in sorghum and that it could be a useful tool to assess inoculum levels before sowing sorghum. Additional management practice changes could also assist in the management of charcoal rot.

"Any practices that minimise moisture stress will help in managing the disease. While it is not possible to predict seasonal conditions, sorghum should be sown into paddocks with good soil moisture, with row spacing and plant densities optimised to reduce moisture stress post flowering," Dr Poudel says.

Clearly, Dr Poudel enjoys her role as a pathogen detective and providing management solutions for the Australian grains industry.

"I am looking forward to continuing to expand my skills and experience, finding novel solutions to support sustainable agriculture and effective disease management." ☐

GRDC Code USQ1807-001RTX

More information: Barsha Poudel, 0402 051 342, barsha.poudel@usq.edu.au

Dr Samir Alahmad holding a soil core taken from the University of Queensland Gatton site to measure the root distribution of newly developed durum wheat lines with modified root traits.

Photo: Associate Professor Lee Hickey, UQ

Roots may unlock improved durum resilience

KEY POINTS

- Detailed investigation of plant roots might provide an avenue for the next yield gains to be made
- Ground-truthing new sensor technology could be a new way to evaluate plant root performance
- New durum germplasm, together with molecular markers, will be provided to Australian breeding programs through a GRDC-supported project at the University of Queensland

For centuries, plant breeders have worked to improve productivity by focusing on above-ground traits to increase yields. However, as the search for yield improvements intensifies, especially in water-limited environments, plant roots are attracting increasing interest.

Dr Samir Alahmad is a GRDC-supported postdoctoral fellow, mentored by scientists from multiple disciplines across several institutes, including the University of Queensland, the Queensland Department of Agriculture and Fisheries, CSIRO and the University of Adelaide. He has been working closely with Dr Lee Hickey's team at the University of Queensland on a project designing roots to enhance durum wheat yields. It builds on the research findings of his PhD research, which was funded by the University of Queensland Research Scholarship and Monsanto's Beachell-Borlaug International Scholars Program.

"As a student in Syria growing up in the wheat growing region of Rojava, I became aware early in my life of the ways in which poverty impacts on the ability of a country to feed its people. Because of this, I chose to study agriculture at the University of Damascus so that I could contribute to the urgent task of satisfying my country's and the world's increasing need for grain, particularly wheat," Dr Alahmad says.

"After moving to Australia 12 years ago, the offer of a PhD scholarship at the University of Queensland gave me the opportunity to follow my passion for crop science and genetics, while also providing a way for me to use my skills to help alleviate global poverty, a cause close to my heart."

BUILDING ON STUDIES

Dr Alahmad's PhD gave critical insights into the genetic control of root architecture and the identification of key regions on genes influencing root growth angle and root biomass that showed promising associations with yield in water-limited environments.

"This foundational work provided the opportunity to combine root architecture traits to potentially improve the adaptive capacity of Australian durum wheat to drought-affected environments."

His current research represents critical GRDC investment in maintaining delivery of new knowledge, innovation and benefits that ultimately assist in enhancing durum wheat yields for Australian growers.

NEW TOOLS

Last year, Dr Alahmad created elite durum lines with unique root trait combinations, which are being evaluated this growing season in 14 Australian environments with GRDC support and collaboration with LongReach Plant Breeders.

Dr Alahmad is using hyperspectral camera sensors on drones ground-truthed with root cores to undertake detailed testing of these lines in different environments. The aim is to validate the traits and determine the optimal root architecture to support yields under varying water-deficit conditions.

"Ultimately the project will deliver elite durum germplasm, together with molecular markers, to Australian breeding companies which will assist in developing new, resilient varieties for growers," Dr Alahmad says.

His goal is to help growers to sustainably implement profitable cropping systems, particularly in the face of drought and climate change.

"As an early career scientist, I am looking forward to further connecting and collaborating with the wider national and international scientific community to exchange novel research ideas and deliver impactful research to meet wheat growers' needs for new knowledge and tools." ☐

GRDC Code UOQ1903-007RTX

More information: Dr Samir Alahmad, 0405 946 915, s.alahmad@uq.edu.au, @samir_alahmad

Learn more about the team that Dr Alahmad works with at the Hickey Lab, http://hickeylab.com/
https://youtu.be/NAQh-FgmgN8

Many mentors shape calling to improve pulses

Supported by a GRDC capacity-building project, Dr Lachlan Lake is on a mission to improve the adaptation and profitability of high-value pulses (chickpeas and lentils) across Australian agroecological zones.

Photo: courtesy Dr Lachlan Lake, SARDI

A career guided by some of Australia's most experienced pulse researchers is ensuring Dr Lachlan Lake is similarly stepping up to deliver advances to growers

■ When he was growing up, Lachlan Lake spent time on a small wool and lamb enterprise on the Fleurieu Peninsula in South Australia, giving him hands-on appreciation for the importance of good pastures and soil management. On rural and interstate road trips with his father, who has always been an enthusiastic advocate for legumes and a dedicated pasture breeder, he also learnt a lot about different crops.

"An agricultural science career seemed like the obvious choice," Dr Lake says.

He obtained a degree in agricultural science from the University of Adelaide, together with an honours degree in 2004 on the yield and potential of faba beans. He was supervised by Dr Jeff Paull, who was to become a lasting mentor. He then gained experience working to improve pulses at the South Australian Research and Development Institute (SARDI) and subsequently looked for novel sources of rust resistance in cereals at CSIRO in Canberra.

In 2010, he returned to SARDI to work on pulse physiology again.

It was here that Dr Lake met another significant mentor – Professor Victor Sadras, a global leader in crop ecophysiology. With Professor Sadras' support, together with a GRDC capacity-building investment, Dr Lake completed his doctorate.

His PhD, supervised by Professor Sadras, Dr Paull and Dr Kristy Hobson (NSW Department of Primary Industries), filled many fundamental gaps on chickpea ecophysiology. He quantified the critical period for yield, delivered a nationwide map of drought stress and heat stress using Agricultural Production Systems sIMulator (APSIM) modelling software, and established connections between growth and yield that became the cornerstone for physiological applications in chickpea agronomy and breeding. His work with Dr Liz Farquharson (SARDI) has also improved understanding of nitrogen fixation in chickpeas.

"This project impressed upon me several integral aspects of conducting successful research, such as proper experimental design and analysis and interpretation of results, and also the value of networking and collaboration to maximise research effort," he says.

Having finished his PhD in 2017, he applied for a GRDC-backed postdoctoral research fellowship to work on a lentil improvement project.

LENTIL LIFT

Lentil production is challenged by waterlogging and Dr Lake estimates that waterlogging affects 60 per cent of Western Australian and 40 per cent of Victorian soils potentially suited to growing lentils, as well as vast tracts of South Australia.

"We developed a new waterlogging tolerance screening method to assess 111 lentil breeding lines and found lines/genotypes with a threefold improvement in growth during waterlogging, as well as a twofold increase in the rate of recovery after waterlogging was removed," he says.

"The data were developed and shared with the Agriculture Victoria lentil breeding program along with the new high-throughput screening protocol. It provided insight into important traits that may be used to enhance tolerance to transient waterlogging in future varieties."

MENTORS FACILITATE NETWORKS

In 2020, Dr Lake's network expanded further as he began a national GRDC-invested project, 'Improving the adaptation and profitability of high-value pulses (chickpea and lentil) across Australian agroecological zones', led by Professor Jim Weller (University of Tasmania) and Professor Sadras.

"I am managing the field phenotyping component of the project with partners in Gatton, Queensland (Dr Fernanda Dreccer), and Merredin, Western Australia (Dr Bob French and Professor Jairo Palta). In conjunction with this, I will be working on a national pulse adaptation project led by CSIRO's Dr Jeremy Whish and Dr Dreccer, aiming to explore and improve pulse adaptation in existing and new environments."

These projects have the added benefit of allowing Dr Lake to become a mentor himself – mentoring students from the University of Adelaide as part of his affiliate lecturer status with the university. □

GRDC Codes UOA1806-024RTX, UOT1909-002RTX

More information: Lachlan Lake, 0418 813 495, lachlan.lake@gmail.com

Photo: courtesy Dr Sarah Rich, CSIRO

Pulse establishment under investigation

Dr Sarah Rich, CSIRO, excavating whole six-week-old lentil seedlings – shoots and root systems – across various depth-of-sowing treatments to assess them for biomass accumulation and growth as part of a GRDC capacity-building project.

Photo: Andrew Toovey, CSIRO

Seven-week-old PBA Striker⁽ᵈ⁾ chickpeas and PBA Bolt⁽ᵈ⁾ lentils. The seedlings have been sown at either 50 millimetres or 200mm (the two in the centre). The photo illustrates the ability for these crops to successfully emerge and establish healthy seedlings even when sown at extreme depths.

Modelling – together with field and pot trials – is showing pulses could be sown deeper and earlier to improve performance in regions of Western Australia

■ As seasonal rainfall and the autumn break become more erratic, it is increasingly challenging to establish crops, particularly in Western Australia's low and medium-rainfall areas. However, new sowing opportunities could present themselves in years where there is an increase in summer rainfall.

This rainfall, together with small autumn rainfall events, can result in subsurface moisture – deeper than 50 millimetres – being available in the sowing window, which may be enough for germination and establishment.

If moisture is present at depth, deep sowing into this moisture would allow growers to sow and establish pulse and cereal crops with less reliance on the season break, potentially offering yield benefits and allowing for more flexibility in their sowing programs.

As a plant physiologist fascinated by the complexity of farming systems, Dr Sarah Rich from CSIRO brings unique insights to a GRDC-supported postdoctoral project, determining how frequently these sowing opportunities could occur and how deep sowing could help plant species, in particular high-value pulses, chase water.

Dr Rich has had an interest in changing rainfall patterns since her doctorate research into the impacts of waterlogging and flooding on native species. She has extended this interest into research into 'management-by-environment interactions' around sowing and emergence in grains.

"Given my interest in below-ground processes, deep-sowing options for Western Australia is a perfect research fit, allowing me to run everything from large field trials to pot studies in the glasshouse," Dr Rich says.

MODEL APPROACH

"We have modelled soil water availability and sowing opportunities over 50 years in the low and medium-rainfall zones of Western Australia. The results have shown that deep sowing could significantly increase sowing opportunity for not only pulses but also potentially oats and long-coleoptile wheat."

Traditionally, pulses are planted at depths of about 50mm, but the modelling work showed that even a small increase in sowing depth, down to 100mm, can significantly increase the number of sowing opportunities.

Closely monitored field trials across three locations and two seasons have been carried out, together with controlled-environment pot experiments assessing genetic variation in emergence and characteristics relating to deep sowing in chickpeas and lentils.

"These trials have shown chickpea and lentil crops can be successfully grown on sands outside the traditional growing areas for these crops in WA," Dr Rich says.

"Chickpeas, lentils, field peas and vetch can be sown in the field to depths of up to 100mm, with little delay to emergence and no significant impact on establishment.

"We also found there is little genetic variation in emergence of common commercial varieties of chickpeas and lentils, and seed size does not affect the emergence rate from deep sowing.

"However, very small seeds will allocate carbon reserve differently to large seeds, resulting in a lower vigour seedling, so there may be a benefit in selecting larger seed size for deeper sowing." □

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More information: Sarah Rich, 0432 891 197, sarah.rich@csiro.au

Grains RD&E Capacity and Ability Framework

Purpose: To ensure enduring access to the talent, infrastructure and delivery pathways that will enable the delivery of GRDC's purpose.

Overview

The Capacity and Ability (C&A) Framework is one of four core frameworks that enable the delivery of grains Research, Development and Extension (RD&E) outcomes aligned to GRDC's strategy and purpose.

To deliver priority RD&E outcomes, the grains industry requires enduring access to highly capable people and appropriate infrastructure in an environment that supports innovation and research for impact.

Framework scope

GRDC's authority to invest in grains industry C&A is limited by its functions under the PIRD Act. requiring C&A investments to relate to:

- The development of persons to carry out R&D;
- R&D to develop the adoptive capacity of Australian grain growers; or
- Dissemination of information, or the provision of advice or assistance, to persons to encourage the adoption of R&D or technical developments designed to improve the grains industry.

This Framework refines the statutory scope of GRDC's investments in C&A to provide greater strategic focus aligned to strategic elements and defined principles.

Principles for C&A investments

- Should ensure enduring benefit to grains RD&E as opposed to delivery of short-term or direct benefit to individuals or organisations only
- Will be highly targeted to deliver RD&E outcomes aligned to GRDC Strategic Plan, identified priorities, C&A framework strategic elements and principles
- Must target unmet needs and not duplicate efforts to address gaps that may otherwise be reasonably achieved through collaboration, partnership or alternative approaches
- Must complement (not substitute) the responsibilities of individual organisations in managing the long-term capacity and ability of their workforce, including professional development
- Seek to leverage co-investment across relevant sectors, organisations and initiatives, considerate of the beneficiaries
- Avoid contributing to the creation of any market failure.

Strategic elements	Guiding principles
Attract and nurture the talent required to conduct and deliver world-class grains RD&E The grains industry has enduring access to people with requisite abilities in the science, extension and commercialisation of R&D to efficiently conduct and deliver priority outcomes	• Should encompass talent critical to grains research, extension and commercialisation across the public and private sectors • Investment will be highly targeted to need and impact as defined by the GRDC strategic plan and communicated priorities • Investment must be considerate of the responsibilities of employers and other relevant stakeholders • Should attract new talent to embark in a career in grains RD&E directly or apply their knowledge and skills through participation • Should nurture and motivate existing talent to continue to apply and develop their knowledge and skills to deliver priority grains RD&E outcomes • Investment to attract new talent should start early, recognising the key influences of career pathways.
Support leadership and pathways to innovate, translate and adopt The RD&E community is well connected and has the leadership and pathways required to inform RD&E priorities, identify innovative solutions, and ensure efficient and effective translation of grains research	• Should encourage divergent thinking to identify new solutions to often long-standing problems • Should target critical leadership skills gaps across the entire grains RD&E pipeline/continuum • Should reach and connect domestic and global expertise to address constraints to grower profitability • Should encourage public and private participation in the commercialisation and adoption of grains research • Should recognise the role of others in grains industry advocacy • Enduring relationships with grains industry participants should be fostered for long-term benefit of Australian grain growers • Collaboration and partnerships should be facilitated and encouraged but are the responsibility of all industry participants in grains RD&E.
Facilitate access to critical infrastructure and technologies required to deliver grains R&D Australian grain growers benefit through access to infrastructure and technologies deemed critical to the delivery of priority grains R&D outcomes	• Should not subsidise the cost of infrastructure that would otherwise be reasonably acquired or accessed by RD&E partners • Investment by GRDC will be proportionate to the benefits to Australian grain growers, considerate of any other beneficiary and use • Ongoing infrastructure access and use arrangements for the purpose of grains R&D should be reflective of GRDC's investment • GRDC should not own or maintain infrastructure.

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