The University Of Queensland
AUSTRALIA

QAAFI
Queensland Alliance for Agriculture and Food Innovation

QAAFI in 2020

OUR MISSION AND VISION

QAAFI's mission is to significantly improve the competitiveness and sustainability of tropical and subtropical agriculture and food sectors through high-impact science.

Our vision is sustainable agriculture and food achieved through science and innovation. We are a world-class connected research institute in crop, horticulture, animal, and nutrition and food sciences delivering industry-driven economic, environmental, and social impact.

Queensland Alliance for Agriculture and Food Innovation

QAAFI in 2020

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Cover photo by Michelle Wignall

AGRICULTURE AND FOOD INNOVATION

Building Better Bioeconomies

Sustainable use of biological resources is key to producing future food, materials and energy.

The Queensland Alliance for Agriculture and Food Innovation (QAAFI) is a research Institute at The University of Queensland that acts as a broker of innovation in agriculture and food.

The University of Queensland is Australia's number one agricultural research institution, and is ranked in the top three globally.

We deliver incremental improvement and transformational change for farming communities locally, while addressing key science and technology challenges for tropical agriculture globally.

Message from the Vice-Chancellor

Sustainable development requires fundamental changes in the way all societies produce and consume food. Against a backdrop of resource scarcity, a changing climate, global population growth and shifting consumer expectations, the world's agriculture and food industries need to affect real change in order to ensure the safe and sustainable production of nutritious food for generations to come.

At The University of Queensland (UQ), we are committed to our mission of knowledge leadership for a better world – including creating and disseminating knowledge that contributes to future food security.

As such, I'm immensely proud that UQ was ranked third in the world for university-based agricultural research in the National Taiwan University's 2020 performance rankings of scientific papers – and we were also ranked as Australia's leading university for agricultural research.

This university has gained global pre-eminence in agricultural research largely because of a decision that we made back in 2010 to create, in a joint initiative with the Queensland Department of Agriculture and Fisheries, the Queensland Alliance for Agriculture and Food Innovation (QAAFI).

From the foundational team of just 34 researchers in 2010, QAAFI has grown to a team of over 400 researchers, Higher Research Degree students, and research affiliates today. And over the course of its first decade, QAAFI's total income has grown from $7.6 million to $53 million in 2020.

Importantly, this growth has enabled QAAFI to broaden its impact on agricultural methods and food production systems – here in Queensland, across Australia and around the world.

Among the many agricultural innovations led by QAAFI, the Hy-Gain project is an ongoing international collaborative research project that is developing high-yielding crops for smallholder farmers in sub-Saharan Africa. Led by Professor Anna Koltunow, with support from the Bill & Melinda Gates Foundation, the Hy-Gain team is harnessing asexual seed formation to increase yields in sorghum and cowpea crops that have been adapted for African conditions.

Other significant innovations emerging from research underway at QAAFI involve high-tech solutions for sustainable crop protection (BioClay), new approaches to protected cropping (growing horticultural crops in glasshouses, vertical farms or protected structures) and predictive-based agriculture, which involves integrating vast datasets with genomic information to optimise the production of crops, pasture, livestock and aquaculture.

These are all exciting initiatives made possibly by the passion of our researchers and students who are committed to sustainable resource use and ethical food production.

The QAAFI team, working with their UQ Faculty of Science colleagues, were instrumental in establishing the Australian Research Council Centre of Excellence for Plant Success in Nature and Agriculture, based at UQ.

Led by Professor Christine Beveridge from the School of Biological Sciences, this $35m initiative involves a number of QAAFI staff working alongside an expert team from four Australian universities, CSIRO, the Department of Agriculture and Fisheries, as well as partners from around the world. The Centre is focused on delivering agricultural innovations that will improve crop resilience, in order to withstand the effects of climate change and increase food security.

After a decade of leading the growth of QAAFI, Professor Robert Henry stepped down as Director in October 2020. I would like to thank Professor Henry for his remarkable contribution – and also welcome Professor Matthew Morell who took up the position as Director in February 2021.

I am confident that Professor Morell will build on Professor Henry's legacy and, in doing so, cement QAAFI's reputation as one of the world's leading research institutes for the study of agriculture and food innovation.

Professor Deborah Terry AO
Vice-Chancellor and President
The University of Queensland

QAAFI: Delivering
IMPACT

The University of Queensland is a global leader in agriculture and food.

Income

$53M Total external income in 2020	$366M Total external income from 2009 to 2020	$637M Total projected income to 2025

People

469 People 2020	**15** Higher degrees awarded 2020	**130** Higher degrees awarded since 2014

Engagement

400 Active projects 2020	**251** Industry presentations 2019	**11** facilities in Queensland and **1** in China

Rankings

The University of Queensland is a global leader in agriculture and food, as measured in different global academic ranking methodologies.

#1 agricultural research institution in Australia *NTU Performance Ranking of scientific papers for world Universities 2020.*	**#3** agricultural research institution in the world *NTU Performance Ranking of scientific papers for world Universities 2020*	**#1** in agriculture science in Australia *QS World University Rankings by Subject [Agriculture & Forestry]for 2020*	**#25** in agriculture science in the world *QS World University Rankings by Subject [Agriculture & Forestry] for 2020*

Visiting the Health and Food Sciences Precinct in 2018: L-R Andrew Cusack, DAF, Yasmina Sultanbawa, QAAFI, Hon Mark Furner, and PhD student Maral Seidi Damye

Message from the Minister

Strengthening Queensland's bioeconomy

The past year has been one of unparalleled events and challenges; the year 2020 was a difficult time for many, with global market instability, natural disasters, including the devastating bushfires, ongoing drought, and the coronavirus (COVID-19) pandemic.

The Department of Agriculture and Fisheries (DAF) manages community resources, applying science to improve production and products, leading the fight on animal and plant pests and diseases, and working constructively with stakeholders for mutual benefit.

A key plank in our strategy is strengthening our agricultural and food industries through world-class science.

To this end, QAAFI was established by the Queensland Government and UQ in 2010, with the primary objective of delivering high-quality, impactful research to benefit Queensland's food and agriculture industries.

In 2020, DAF evaluated its investment in QAAFI, recognising QAAFI's outstanding success in generating over half a billion dollars of contracted research income in little over a decade to work on key challenges affecting our tropical and sub-tropical production systems.

QAAFI's success is also demonstrated by its excellent reputation with grower and producer groups, and its high standing nationally and internationally.

During the past five years, QAAFI has increased its agriculture and food science capability and capacity by 36 per cent with an increase in research staff and 85 postgraduate student completions.

This larger critical mass of quality scientists has fostered improved momentum, resilience and sustainability in QAAFI, stimulated significant infrastructure improvements in several locations, and boosted Queensland's agricultural research capabilities.

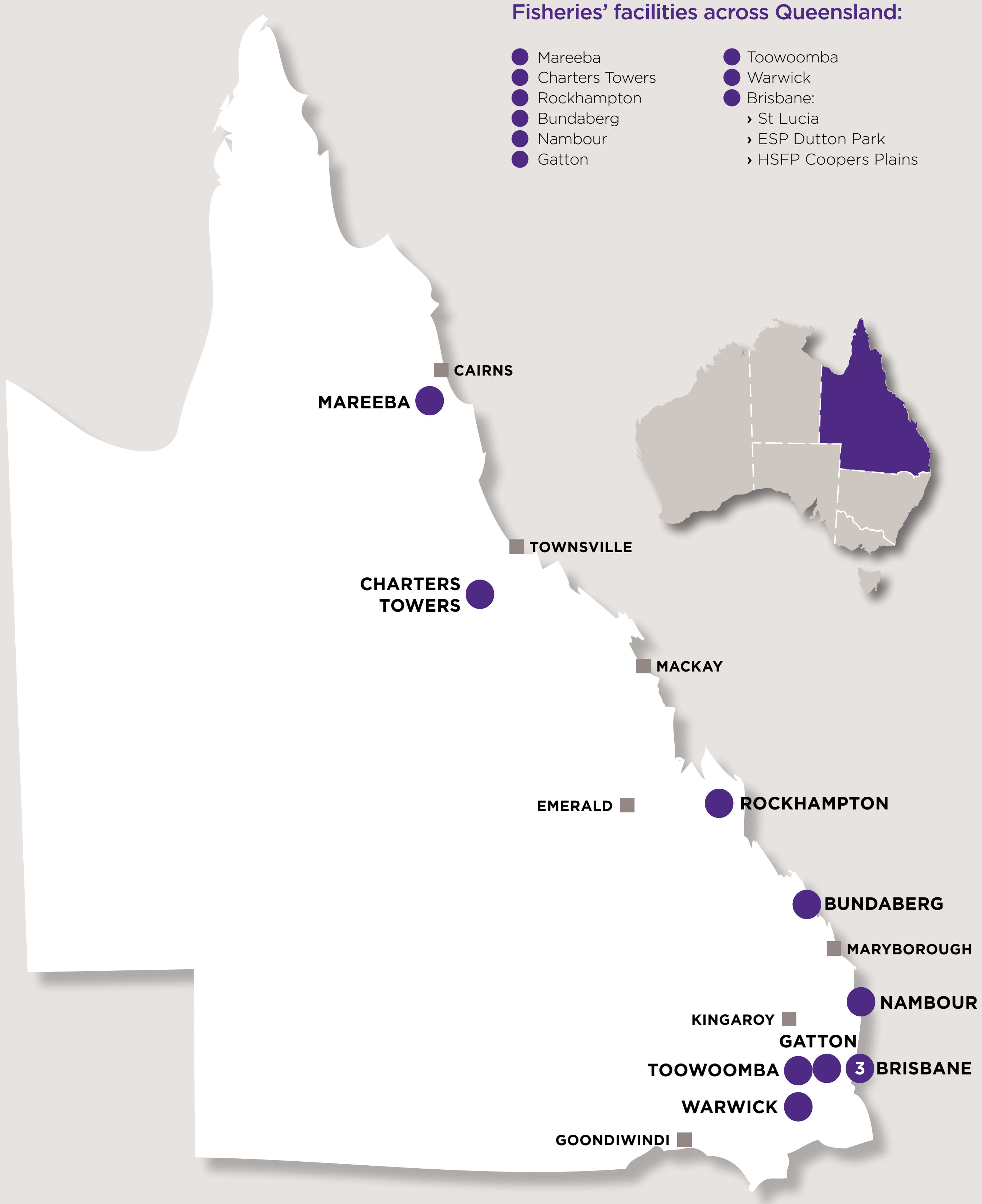
It is critical we maintain this momentum for the future of Queensland's burgeoning bioeconomy, where agricultural science will enable us to not only meet the state's need for food, energy and industrial products, but also unlock the untapped potential of biological waste and residual materials.

Honourable Mark Furner MP
Minister for Agricultural Industry Development and Fisheries and Minister for Rural Communities

QAAFI in Queensland

Our researchers are co-located with Department of Agriculture and Fisheries' facilities across Queensland:

- Mareeba
- Charters Towers
- Rockhampton
- Bundaberg
- Nambour
- Gatton
- Toowoomba
- Warwick
- Brisbane:
  - St Lucia
  - ESP Dutton Park
  - HSFP Coopers Plains



Director’s message

Eyes on QAAFI, as new Director is appointed


Professor Matthew Morell


Professor Robert Henry

With its headquarters at The University of Queensland’s St Lucia campus and 11 regional sites statewide, the organisation better known as QAAFI welcomes a new director in February 2021, following the decision of founding Director, Professor Robert Henry, to step back from frontline management late last year. Read more in the following article, published in *InQueensland* in February 2021.

The arrival of Professor Matthew Morell from the Philippines, where he was director-general of the International Rice Research Institute, marks the next phase of QAAFI’s evolution from a start-up 10 years ago to an internationally recognised research body on the cusp of delivering new innovations ripe for commercialisation.

Professor Morell has stated his intention to drive QAAFI as the lead vehicle to propel UQ as the world’s leading university for agriculture and food in sub-tropical and tropical regions.

In his last interview as QAAFI Director, Professor Henry, who has stepped back to focus on his own research projects, said the pipeline from scientific discovery to market realisation was long and unpredictable, but the timing was now about right for some of those projects under QAAFI management to generate commercial interest with lucrative contracts.

“Some of the projects we have in development could lead to very big outcomes,” Professor Henry said.

“It’s not a question of if, but when, and that’s no accident. You always have to keep an eye on the market and review who the customer is and what they want.

“Unless you’re doing that you really run the risk of producing something that’s not needed or missing the opportunity to extract value.”

One of those projects with a long pipeline, but potentially massive rewards at the other end, is the drive to create macadamia nuts with thinner shells and a larger kernel.

Started more than 25 years ago, the project’s aim is to increase yield, while still maintaining a tough enough shell to resist pests and diseases.

Funded by the Queensland Government, it is important work benefiting the crop native to south-east Queensland, given researchers estimate the macadamia is currently yielding 30 per cent below its potential, yet remains Australia’s second biggest nut export, projected to be worth $350 million annually by 2025.

Funding for QAAFI projects comes via a mix of public and private money.

The Queensland Government is a major backer, but so too is the Bill & Melinda Gates Foundation, which has invested $4 million in 2013 to improve sorghum productivity under drought conditions and further funding last year to accelerate fertility gains or ‘hybrid vigour’ from sorghum and cowpea seed.

The project is expected to be game-changing for farmers in developing countries, but will also assist farmers in Australia to lower planting costs and improve crop yield on soils compromised by variable climate.

Another project based on the discipline of nanotechnology, the science of combining engineering and technology at the minuscule scale, harbours the potential to produce food crops capable of self-resisting plant diseases and pests, all but eliminating the need for chemical crop protection agents such as insecticides and herbicides.

Nanotechnology brought success to QAAFI in 2011, with the creation of the world’s first vaccine for Bovine Viral Diarrhoea Virus, known in the livestock industry as BVDV.

Uniquely placed

Since its inception a decade ago, QAAFI has identified projects with “global significance and local relevance”, according to Professor Henry.

“This was particularly relevant for Queensland, which has always invested strongly in agriculture due to the fact the industry remains critically important to the state’s economy,” he said.

“Agriculture in Queensland is diverse, possibly more diverse than anywhere else in Australia.

“There are a lot of subtropical and tropical crops you can grow in Queensland that you can’t grow anywhere else.

“That alone is unique, but there aren’t other developed countries with these types of environments.

“You can do research on crops in subtropical and tropical environments elsewhere in the world, but they won’t be in first-world countries with modern farming systems, equipment and developed infrastructure.

“That’s what makes our research world-leading and highly sought after at the international level.”

“Why the world’s agricultural experts have their eyes on Queensland” was written by Brad Cooper and published by InQueensland *on 15 February 2021.*

Research themes

CENTRE FOR *Crop Science*

Themes
- Crop improvement
- Crop physiology and modelling
- Farming systems and agronomy

CENTRE FOR *Horticultural Science*

Themes
- Emerging technologies
- Plant protection
- Horticulture crop breeding and agronomy

CENTRE FOR *Nutrition and Food Sciences*

Themes
- Smart selections
- Naturally nutritious
- Uniquely Australian

CENTRE FOR *Animal Science*

Themes
- Pests and diseases
- Production systems
- Animal welfare

QAAFI Advisory Board

The QAAFI Advisory Board (QAB) provides strategic advice to grow QAAFI's research capacity and help the organisation meet the global demand for safe food and improved nutrition.

Board members act as advocates for QAAFI. They also generate important connections with government, industry and the community.

QAB members provide input into each Centre's academic quality and industry impact, and are also tasked with overviewing the Institute's financial health, diversity of funding sources and administrative efficiency.

The Board plays an important role in reviewing the effectiveness of QAAFI's communication with key stakeholders, and has been vital in providing QAAFI with strategic advice and direction.

The current Board has outstanding representation across academia, government and industry, with members generously providing significant time and effort at formal Board meetings as well as other events and activities.

While advisory in nature, the QAB has kept QAAFI focused on the need for high-quality science translated into outcomes with real impact for QLD, the nation and the world.

QAB's current membership includes:

Mr John Chapman

(Chair) Former Executive Director of Agri-Science, DAF

Dr Brian Keating

Former Executive Director, CSIRO Agriculture, Food and Health

Mr David Crombie AM

Agribusiness industry leader

Ms Sarah Meibusch

Investment Manager, OneVentures and former Deputy Director, QAAFI

Ms Bernadette Ditchfield

Deputy Director-General, Agriculture, DAF

Dr Mirjana Prica

Managing Director, Food Innovation Australia Ltd

Professor Bronwyn Harch

Deputy Vice-Chancellor (Research and Innovation) and Vice-President (Research and Innovation), UQ

Growing QAAFI

As one of the few research–intensive universities in the world that is located in a subtropical environment, UQ is a global leader in agriculture and food science research for subtropical and tropical production systems.

QAAFI is a research hub that not only undertakes incremental research to address current agricultural issues, but also develops transformational technologies that represent a step-change in agricultural and food production systems.

QAAFI contributes to this global leadership by facilitating extensive industry linkages; creating connections to global expertise; and by enabling access to research infrastructure across a broad range of interconnected disciplines.

QAAFI's success over the past decade is due to the endeavour, commitment and innovative spirit of its people.

WU-ING *the world*

Research success for Dr Alex Wu

Dr Alex Wu has played a key role in developing a model that predicts how photosynthetic adjustments to plants can boost the yields of wheat and sorghum crops.

This work was undertaken in the ARC Centre of Excellence for Translational Photosynthesis (CoETP) and at The University of Queensland (UQ).

QAAFI researchers, led by Dr Alex Wu *(pictured)* supervisor, Professor Graeme Hammer, developed the model as a way of linking photosynthetic leaf function to field performance of crops, to improve important traits like growth and yield.

"We developed a reliable, biologically-rigorous prediction tool that can quantify the yield gains in realistic crop environments associated with manipulating photosynthesis," said Dr Wu.

Plants convert sunlight, carbon dioxide and water into food through photosynthesis and several studies have shown that this vital process can be engineered to be more efficient.

Dr Wu's model is a cross-scale crop physiology model that operates from photosynthesis biochemistry in the leaf and connects with crop growth and yield prediction at field scale for sorghum and wheat.

The model has been finalised, published, and implemented in the APSIM computer simulation framework.

Dr Alex Wu received an Australian Research Council DECRA (Discovery Early Career Researcher Award) to continue this model-based crop improvement research. Dr Wu (full name Dr Chung-Chi Wu) was awarded $461,249 by the ARC to discover new avenues for crop improvement and significantly benefit crop breeding and food production capacity, using the cross-scale modelling approach in key crops.

In 2020, he was also awarded the Australian Society of Plant Scientists (ASPS) prestigious Peter Goldacre Award, one of the premier research awards from ASPS. The award honours the memory and attainments of Peter Goldacre – a young scientist and foundation member of ASPS.

The Award is made on the merit of original research by an early career researcher in one area, the findings of which have been published, or accepted for publication.

Previous winners have included TJ Higgins, Graham Farquhar, and Christine Beveridge.

As part of this award, Dr Wu presented his work in a plenary Goldacre Lecture via a virtual seminar through the Plantae Webinar series, organised by the American Society of Plant Biology.

Dr Wu was also awarded QAAFI's inaugural Rising Star Award in 2020, to cap a stellar year.

BIODIVERSITY *expert appointed*

Growing Australia's bush foods industry

Mr Maylla Wunungmurra from Gulkula Mining in Arnhem Land with researchers on the Uniquely Australian Foods project Prof Philippe Schmitt-Kopplin from HelmholtzZentrum Munchen and Technical University of Munich in Germany and Ms Selina Fyfe, QAAFI.

Indigenous rights activist and expert in Indigenous intellectual and cultural property and heritage, Professor Henrietta Marrie AM, has joined the ARC Uniquely Australian Foods (UAF) Training Centre, based at The University of Queensland.

Professor Marrie, pictured right, will provide advice on the strategic direction of UAF research and best practice protocols to protect the rights and interests of Indigenous project participants.

UAF Director, Professor Yasmina Sultanbawa, said Professor Marrie would play a critical role in driving the Australian native foods industry forward.

"We are working with Indigenous communities across Australia, food industry entrepreneurs, and a research team spanning law, engineering, food science and the social sciences to create a new agri-food sector based on Australia's remarkable native bush foods like Kakadu plum (also known as Gubinge).

"Professor Marrie brings a wealth of experience to UAF and will help shape the industry, while ensuring the cultural heritage and traditional knowledge of foods eaten by Australia's First Peoples over many thousands of years will be sustainably developed and benefits shared amongst communities."

"I am a Gimuy Yidinji woman of Cairns, born and raised in Yarrabah," Professor Marrie said.

"My interests include biocultural diversity, Indigenous intellectual property, and traditional ecological knowledge.

Professor Marrie was the first Aboriginal person from Australia to be selected for a full-time professional position with the United Nations agency, the Secretariat of the Convention on Biological Diversity of the United Nations Environment Programme based in Montreal, Canada.

"As an activist I have fought for the recognition of Aboriginal peoples' intellectual property and cultural rights and particularly for access to and repatriation of ancestral remains, cultural objects and important historical information from national and state museums and archives," Professor Marrie said.

Professor Marrie (née Fourmile) has produced over 100 papers and reports in academic journals, and has chapters in many edited books. She has a Masters in Environmental and Local Government Law at Macquarie University, and is a Member of the Order of Australia for her significant service to the community as an advocate for Indigenous cultural heritage and intellectual property rights, and to education.

Her publications cover Indigenous arts, cultural heritage policy, critical essays on the role of museums as custodians of Indigenous cultural property, and the role of native title in the protection of Indigenous natural heritage rights and protection of biodiversity-related knowledge, access and benefit-sharing and the role of Traditional Owners in protected area management.

Biotech HERO

We need another hero!

Professor Ian Godwin named BioTech FoodHero by CropLife International.

Professor Ian Godwin believes that genetically modified (GM) foods are "good enough to eat" and he is passionate about reassuring the public that science backs him up.

In 2019 he even published a popular book on that topic –serving up an easily digested explanation of the science behind agricultural biotechnology and a peek at what the future might hold.

But for Professor Godwin, Director of QAAFI's Centre for Crop Science at the University of Queensland in Brisbane, taste and safety are just two characters in the bigger GM sustainability story. GM crops are one way to ensure a happy ending.

"Very simply, the improved yields and reduced use of fertiliser and pesticide enabled by biotechnology can benefit people and the natural environment," Professor Godwin said.

"I live and work in Australia, where our greatest challenge has always been water.

"Climate change for Australian farmers is already leading to hotter, drier conditions, and more unpredictability, which is going to make producing enough quality food even harder."

Professor Godwin says he got "hooked" on biotechnology while working on a GM sugar beet project during his post-doctoral work in the United Kingdom.

He later pioneered the use of biotechnology in sorghum, adding value to this important and versatile livestock feed crop by developing varieties with larger grains, higher protein content, and improved digestibility.

Professor Godwin enjoys mentoring young scientists to help them achieve their full potential, while also advancing the next generation of GM crops.

"Once all farmers have access, the benefits will be widely recognised," he said.

Brave new world of AGRICULTURE

Agriculture in a post-pandamic world

As QAAFI staff and students adapted to restrictions imposed by the COVID-19 pandemic in order to minimise impacts on the delivery of research projects, Professor Robert Henry reviewed the innovations in agriculture and food that will help secure food supply in the face of future pandemics.

Robots working in abattoirs, sky-high vertical farms, more gene-edited foods in our supermarkets and automated farming systems could all help guarantee food supply in the next pandemic.

Professor of Innovation in Agriculture at QAAFI, Robert Henry, said the technologies had all been in various stages of planning prior to COVID-19, but food producers would now be moving much faster to prepare for the next pandemic.

"Food processing facilities like meat works have had to close due to a staff member being infected with the coronavirus, and all food processing industries where you have workers in small, confined spaces are similarly at risk," Professor Henry said.

Professor Henry said roboticised abattoirs and automated harvesting and production facilities would also reduce the risk of transmission of pathogens among workers but also the spread of viruses via the food itself.

"COVID does not seem to be transmissible from an infected human touching food but a future pandemic virus might be transmitted this way, so automating the food supply chain reduces this risk. It also minimises reliance on human workers that are not available due to migration restrictions and border closures."

Professor Henry said protected cropping, including vertical farms – or growing food in vertically stacked layers similar to a skyscraper building – would optimise plant growth and enable control over climate variations, chemical inputs and water resources.

"There will have to be policies that drive consumer acceptance of gene edited foods, which some consumers consider as GMOs.

"Advanced technologies need to be adopted globally, in each region, to deliver local food production capability that could provide secure sources of food in future pandemics.

"We will need to design crops to suit automated systems – for example for fruit to grow in places where it can be harvested robotically."

Professor Henry said the ongoing COVID-19 pandemic made it difficult to fully assess the impact on agriculture and food supply.

He said despite growing stocks of foods such as cereals, it was estimated the number of people facing a food crisis will grow from 135 million to 265 million by the end of 2020.

"It may seem to those of us in Western countries that the only impact on food supply has been a rush on pasta and rice in the supermarket and home-baking, but the loss of income caused by the pandemic has hit some countries in Africa hard.

'We are in a situation where we have food surpluses while there has been a doubling in the number of people who can't afford to eat – and the situation is likely to get worse."

Professor Henry said increased investment in agricultural research and development would support enhanced food security.

HARVESTING *beef data*

Black Box's digital beef production

At QAAFI, Shannon Speight works on a large-scale beef genomics project across Northern Australia. The project involves over 50 properties from Queensland, the Northern Territory and Western Australia, ovarian scanning over 30,000 heifers to develop a DNA suitable for northern cattle, focused on fertility traits.

Now she has founded Black Box Co, an innovative SaaS (Software as a Service) product that ingests raw data across the beef supply chain to inform prediction, forecasting and key production insights.

Shannon Speight is on a mission to help cattle growers boost profits and sustainability.

Partnering with Emma Black, the two women are collaborating on new tech start-up, Black Box Co.

Ms Speight, who works on the ground-breaking northern genomics beef industry project with QAAFI's Professor Ben Hayes, said agriculture was stuck in the past.

"There's so many amazing innovations that have gone on generating more and more data," she said.

"Now we need to use that data in a really smart way to affect real on-ground decisions."

Ms Speight is a vet with a background in cattle breeding, fertility and genetics. She founded Black Box last year.

Black Box is an analytics platform that draws on data to help cattle growers make better decisions on farm and animal management.

"We are looking at how cattle are performing, and we are able to look at the best performers and the worst performers," Ms Speight said.

It is a platform that integrates data from farms, including animal weights, pregnancy status, and where they have been grazing.

The Black Box platform also pulls information from abattoirs, such as carcass weights, bruising and scaring, and fat colour and meat colour.

Black Box Co underwent the SparkLabs ag-tech accelerator program earlier this year and now employs six full-time staff.

"At the moment, there's no way for all of that data to speak to each other and start to inform some decisions on-farm.

"So, we ingest all of that data in its raw form, run it through our algorithms and our machine learning in order to create really useful insights."

"What we really want to do is bring agriculture, and especially livestock production, into the 21st century, where we can confidently make decisions based off data, which increases the profitability, the productivity and the sustainability of the beef industry."

Black Box helped a pastoral company identify a $750,000 opportunity loss due to carcass discounts – meat is discounted if it is bruised or has scars, is underweight (as in this situation) or if the fat is too yellow – at the abattoir.

The farm managers were then able to shift the animals to a fattening property with better nutrition to ensure that the next lot of beasts were at the optimum weight.

At another property, they identified calf deaths worth $76,000 in just four months, showing it was a seasonal calf loss with too many born at a time of poor nutrition – the analytics providing enough information to know when to put the bull in with the heifers and when to take it out.

"There's a lot of things we can do," Ms Speight said.

"We've got a lot of good producers. We're going to have to collect more and more data going into the future to be able to actually verify what we're doing on-farm and show how we're managing our land sustainably."

Based on article written by Christopher Niesche for Westpac News *in November 2020*

DECRA SUCCESS

For Dr Kai Voss-Fels

Dr Kai Voss-Fels

Dr Kai Voss-Fels and his QAAFI colleague, Dr Alex Wu, were two out of just 200 successful applicants for 2021 funding submissions under the Australian Research Council's (ARC) Discovery Early Career Researcher Award scheme.

In November 2020, the then-Minister for Education Dan Tehan announced funding for 200 research projects led by young Australian researchers deemed to be in the national interest.

Dr Voss-Fels received $447,524 to investigate how biological and environmental data can be integrated to improve the prediction of plant performance under climatic fluctuations.

The project aims to generate new knowledge in the area of quantitative genetics, that is, genetic variation among individuals within phenotypes.

Dr Voss-Fels completed his PhD and postdoc at the Justus Liebig University Giessen in Germany in 2016 with highest distinction (*summa cum laude*, JLU best dissertation award).

Dr Voss-Fels is interested in developing and implementing new genomics-assisted breeding approaches to improve yield, quality and resistances in major crops, such as wheat, barley, sugarcane, rapeseed and chickpea.

A particular focus of his research involves the integration of quantitative genetics, genomics, and computational approaches to develop new crop improvement strategies.

He is particularly interested in new genomic prediction approaches, e.g. involving artificial intelligence and computer simulation, which could help to accelerate the rate of genetic gain.

This also includes the study of the gene and environment (GxE) interaction and non-additive genetic effects, which represent a key challenge for crop genetic improvement programs.

Dr Voss-Fels's 2019 Nature Plants publication looked at the genetic diversity within the relatively narrow modern wheat gene pool.

The research compared 200 wheat varieties, essential to agriculture in Western Europe over the past 50 years, under contrasting input levels of mineral fertilisers and plant protection chemicals.

Dr Voss-Fels estimates genetic diversity within the relatively narrow modern wheat gene pool is rich enough to potentially generate a further 23 per cent increase in yields.

The findings also show that highly cultivated modern wheat varieties outperform older varieties, even under conditions of reduced amounts of fertilisers, fungicides and water.

Emerging science LEADERS

QAAFI's innovative team of early and mid-career researchers took to Zoom to showcase their research during an all-staff meeting in November 2020.

Presentation winners were: (Best speaker) Dr Anne Sawyer for her presentation RNA-based biopesticides for next-generation crop protection. (Runners-up) Dr Bradley Campbell - DNA fingerprinting, curating and conserving the Pacific islands' principal stable crop, taro (Colocasia) and Dr Karen Massel - Hotter, drier, CRISPR: Modifying cereal architecture for a water-limited world.

Thanks to all who entered, and to the QAAFI EMCR Group, who coordinated the event.

L-R: Dr Brad Campbell, Dr Anne Sawyer, Dr Karen Massel

CREAM *of the Crop*

Queensland Agriculture Awards

Outstanding contributors and innovators in agriculture, fisheries and forestry were recognised by Minister for Agricultural Industry Development and Fisheries The Honourable Mark Furner at the annual Queensland Agriculture Awards, announced at the AgFutures 2020 virtual forum in Brisbane in September 2020.

Darling Downs farmer and former Queensland Farmers' Federation President Stuart Armitage won the prestigious Peter Kenny Medal, and Jerome Leray, who founded AgTech company InFarm, was named the Minister's Emerging Leader Award winner.

QAAFI's Dr Elizabeth Worrall, from the Centre for Horticultural Science, was named a finalist in the Minister's Emerging Leader Award finalists.

Having played a leading role in the QAAFI Early Career Research network in 2020, Dr Worrall said she was honoured to be recognised by the Department.

Congratulations to all 11 QAAFI Higher Research Degree (HDR) students who presented their work via Zoom to all QAAFI staff and students on 1 December 2020. Winner of the best HDR student presentation was Mr Muhammad Noman Naseem, and the Runner-up award was Mrs Christie Warburton, both from the Centre for Animal Science. Additionally, Ms Ai Chin Teo (BBiotech QAAFI/SCMB) won people's choice award for best Honours/Masters student presentation.

Research excellence

Professor Bhagirath Chauhan

WEED *Science Society*

Recognition of meritorious service

QAAFI's Professor Bhagirath Chauhan was named an Honorary Member of the Weed Science Society of America (WSSA) in March 2020, at the organisation's annual meeting in Maui, Hawaii.

"This year's honorees are making significant contributions to weed science through their research, teaching, publishing and outreach," said Bill Curran, annual meeting program chair and incoming president of WSSA.

The Honorary Member Award is given to an individual who has performed meritorious service in the field of weed science.

Only one Honorary Member is selected per year. Congratulations, Professor Chauhan!

Distinguished Fellowship AWARD

Contributions to organic chemistry

In recognition of her valued contributions to organic chemistry and the Queensland Branch of the Royal Australian Chemical Institute (RACI), the Board of RACI have awarded Professor Mary Fletcher with a Distinguished Fellowship.

Professor Mary Fletcher

Dean's AWARD

Outstanding HDR theses

Congratulations to Dr Thi Nga Tran for winning a Dean's Award for Outstanding Higher Degree Research (HDR) Theses in 2020.

Dr Tran studies the biology and epidemiology of citrus black spot *(Phyllosticta citricarpa)* in Australia.

The Dean's Award for Outstanding Higher Degree by Research Theses gives formal recognition to outstanding PhD and MPhil graduates who have been commended by their thesis examiners.

All examiners are given the opportunity to nominate a candidate for the Dean's award if they feel the standard of the thesis is exceptional and makes an outstanding contribution to the field of research.

Dr Thi Nga Tran

Plum AWARD

AIFST poster winner

Gethmini Kodagoda

Gethmini Kodagoda's poster titled "Impact of storage on phytochemicals and sugars in Queen Garnet plum" won the 1st Place at the Research Poster Competition at this year's AIFST Virtual Convention. Gethmini is working on Queen Garnet plum and plumcots in the Hort Innovation-funded Naturally Nutritious program. Well done, Gethmini!

Dr Lilia Costa Carvalhais on a field trip in PNG.

BANANA-PANORAMA

International Engagement Award

The Crawford Fund Queensland Committee supports targeted training and mentoring of overseas scientists and extension officers by experienced Queensland counterparts working on similar agricultural research challenges.

In May 2020, Dr Lilia Costa Carvalhais, Research Fellow from QAAFI's Centre for Horticultural Science, was awarded one of four International Engagement Awards being made to trainers and mentors from James Cook University, University of Southern Queensland and The University of Queensland.

Dr Carvalhais said she is driven by curiosity to understand the overwhelming complexity of the biological world and the interactions between plant and microbes.

She currently studies the biology, distribution and epidemiology of banana diseases, banana Fusarium wilt, banana wilt associated phytoplasma (BWAP), Black Sigatoka, Eumusae leaf spot, Moko (Bugtok), banana blood disease, Xanthomonas wilt and Freckle.

Dr Carvalhais received the Crawford training and mentoring award for her project, 'Reducing the risk of emerging banana diseases in PNG'.

Professor Bob Lawn, Coordinator of the Crawford Fund's Queensland Committee, said while associated travel could only be undertaken according to the Australian Government, the committee was pleased to support a diverse set of training and mentoring in industries of significance to both Queensland and neighbouring countries, including Timor-Leste, Papua New Guinea (PNG), the Pacific and Indonesia.

Dr Carvalhais was supported by the Committee to facilitate a workshop in Workshop in PNG on diseases of banana for regional attendees from the National Agricultural Research Institute and the National Agriculture Quarantine and Inspection Authority.

Other workshop presenters include Dr Kathy Crew, QDAF (a 2019 Crawford-in-Queensland awardee – photo below) and Dr Richard Davis (DAWR&E Northern Australian Quarantine Strategy).

ANIMAL SCIENCE

Leading tropical livestock research and development

The Centre for Animal Science delivers world-class research to Australia's animal industries.

We aim to increase on-farm productivity and sustainability in the northern Australian beef industry and across the livestock industries, including pigs and poultry.

We have major programs and capability in genetics and genomics; breeding and reproductive capability of northern Australian cattle breeds; welfare and ethics; pest and disease control through improved detection; monitoring and vaccine technologies; nutrition; metabolism and growth.

Research themes:

- Animal welfare
- Pests and diseases
- Production systems

Blueprint to more productive cattle herds

Genome technology has unlocked new cattle breeding methods that could improve fertility and lead to increases in profitability, sustainability and productivity.

University of Queensland researcher Professor Ben Hayes *(pictured)* co-developed the technology – called genomic selection – which could produce differences in fertility that result in up to three extra calves over a cow's lifetime.

"With global beef production forecast to fall 17 per cent in 2020-21, the gain this technology can provide is important for strengthening the global supply of this high-value protein," Professor Hayes said.

"Another benefit is cows that produce more calves over their lifetime have lower methane emissions per kilogram of beef, which improves the sector's sustainability."

Genomic selection technology uses DNA markers across the cattle genome to predict traits such as fertility that are affected by large numbers of genes.

To do this, very large data sets where both the DNA markers are profiled (genotyped) and fertility is recorded are required. Once this is achieved, young bulls and heifers with specific DNA profiles indicating high fertility genetics can be selected for breeding.

To build such a data set, Professor Hayes has been working with 54 collaborator herds across Northern Australia.

"So far we've genotyped more than 30,000 cattle using sets of 35,000 DNA markers that allow us to detect subtle genetic differences between animals," Professor Hayes said.

"For key bulls that have contributed important genetics to breeding programs, we upped that to 700,000 markers, resulting in more than 21 billion data points to analyse.

"The larger the data, the more accurate the DNA profile tests are, which means the bulls and heifers can be selected for breeding very early, potentially at birth – or even as embryos."

Professor Hayes and his team said the technology was now at the point where it could produce fertility predictions based on a DNA test, and these predictions have been delivered back to the participating herds for their animals.

The participating herd owners included Russell and Donna Lethbridge, who own the Werrington Cattle Co, based near Hughenden in North Queensland.

This region has experienced high breeder mortality rates and low reproduction rates due to native pasture nutrition that is well below required levels.

Mr Lethbridge sought to overcome these disadvantages by targeting fertility traits over the past 25 years – first using selective breeding and now Professor Hayes's breeding values.

"By targeting fertility, we've indirectly selected for adaptations to our environment and that allowed for a reduction in age and weight at puberty that has made a huge difference to productivity," Mr Lethbridge said.

With his Brahman heifers reaching puberty at 20 months, his herd is operating at 20 per cent above the district average for reproduction efficiency.

The project was funded by MLA Donor Company, the Department of Agriculture and Fisheries in Queensland, and The University of Queensland.

Genetic link between cattle temperament and autism

A strong association between the genes influencing cattle temperament and autism in humans has been discovered by University of Queensland researchers.

Director of QAAFI's Centre for Animal Science, Professor Ben Hayes, said the research by his interdisciplinary team headed by Dr Roy Costilla could lead to improved animal welfare and meat quality.

"The research doesn't mean that cattle have autism; rather that cattle share an overlap of genes with humans that are critical in brain function and response to fear stimuli," Professor Hayes said.

Temperament is an important trait for day-to-day management of cattle.

"We knew that genetic factors were likely to influence temperament in cattle and we thought that genes involved in behavioural traits in humans could also influence temperament in cattle.

"We found that genes known to contribute to autism spectrum disorders also influence temperament in cattle."

Professor Hayes said the results were important as they opened the way for research conducted on behavioural traits in humans to shed further light on temperament in cattle.

"As I've found talking to farmers over the years, it can be distressing having an animal that has a poor temperament in the mob, and stirs up all the other cattle, putting them into a state of stress.

"If we can identify those animals early, or breed to eliminate them, we can potentially reduce the stress of the whole mob.

"That has great implications for welfare – not only of the cattle but also the people handling the cattle who are less likely to be charged or kicked."

Professor Hayes said there was an association between a calmer temperament in cattle and better meat quality.

"The cattle industry's standard for measuring temperament is 'flight time' – the speed at which cattle move after release from an enclosure," Professor Hayes said.

"What a producer wants is cattle that move calmly and slowly from the enclosure, rather than an animal that charges out in an aggressive or stressed state.

"Our study found flight time is about 35 per cent heritable, which is very significant.

"It means you can make a lot of progress by breeding for better temperament – it's about the same as milk production in dairy cattle, and we've made big breeding gains there."

It's the first time whole-genome sequencing has been used to analyse temperament in beef cattle.

Researchers looked at 28 million data points per animal on the 9,000 cattle with temperament records in the initial study, and then validated the results in over 80,000 cattle from Ireland.

Professor Hayes said his team would incorporate the temperament data into a panel of markers available for producers that would also provide breeding values for fertility.

The temperament analysis was conducted primarily in northern cattle *Bos indicus* breeds and was validated in *Bos taurus* cattle.

The study was a result of strong cooperation between Australian researchers, the beef industry and collaborators from Ireland and Brazil.

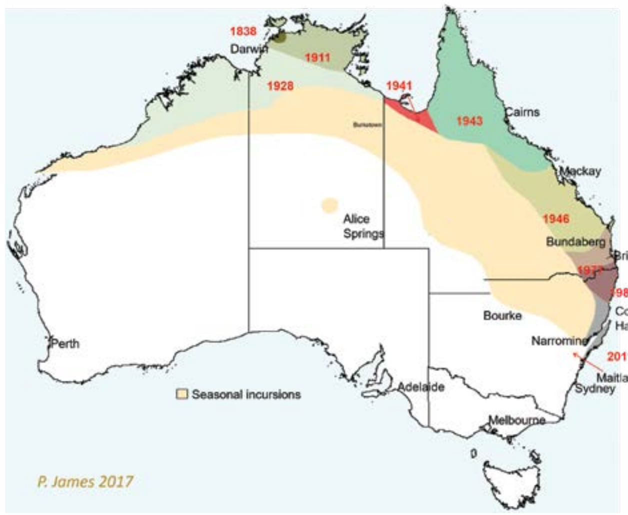
Buffalo fly faces Dengue nemesis

Few southern beef producers will have encountered the parasitic buffalo fly (*Haematobia irritans exigua*), a scourge of the northern cattle industry – but maintaining this state of affairs, and also lifting a burden off the northern industry, has become a race against time, and climate.

Buffalo fly is a serious animal health and production challenge, costing the northern industry almost $100 million a year in treatments and lost production. But control of the pest with insecticides is running into increasing resistance, plus there is a need to protect Australian beef's 'clean green' reputation and so minimise the need for pesticides.

Over the past century, the buffalo fly has been creeping southwards through Queensland to northern NSW, and modelling shows that, aided by climate change, it could reach as far south as South Australia and south-west Western Australia by 2030. The blood-sucking fly causes large, painful sores, and distressed animals can be distracted from feeding enough to seriously affect growth.

Buffalo fly spread in Aust



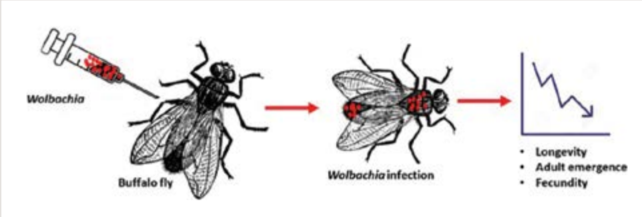
The only obstacle in its path is a joint university, industry and Queensland Government biological control project using the insect-infecting bacterium, Wolbachia – the same agent that has been used so successfully to suppress mosquito-transmitted dengue fever in humans.

The project is led by Dr Peter James *(pictured)* (QAAFI) who explains the key is using the Wolbachia bacterium to break the fly's breeding cycle. If this can be sustai ned, it presents an opportunity to both suppress the buffalo fly population in the north and stop its spread southwards.

The buffalo fly is a formidable foe, having been introduced from Asia into the Northern Territory in the late 1830s, but the chink in its armour is that it weakens in cold weather. Its populations tend to shrink into localised pockets. Dr James says if Wolbachia can be used to further stress the buffalo fly in winter, then a local eradication strategy starts to become a real possibility.

But there are some considerable technical challenges still to overcome. Because the bacterium is spread vertically from mother to offspring, not transferred sideways among flies, buffalo flies have to be artificially infected by microinjection. With mosquitoes, this is usually done by microinjection into the eggs. That approach hasn't been able to be used for buffalo fly because the eggs are extremely hard: "When we started micro-injecting eggs, as is done with mosquitoes, we were blunting needles and damaging the eggs like you wouldn't believe. Needles were even breaking," says Dr James.

"So from there we looked at micro-injecting adult flies or pupae, the idea being the bacterium would still spread through the insect and get into the germinal tissue of the females."



Transinfection of buffalo flies with Wolbachia tested for widespread control. Image by Dr Mukund Madhav (James lab) and published in Madhav, M., Brown, G., Morgan, J.A.T. et al. Transinfection of buffalo flies (Haematobia irritans exigua) with Wolbachia and effect on host biology. Parasites Vectors *13, 296 (2020). https://doi.org/10.1186/s13071-020-04161-8*

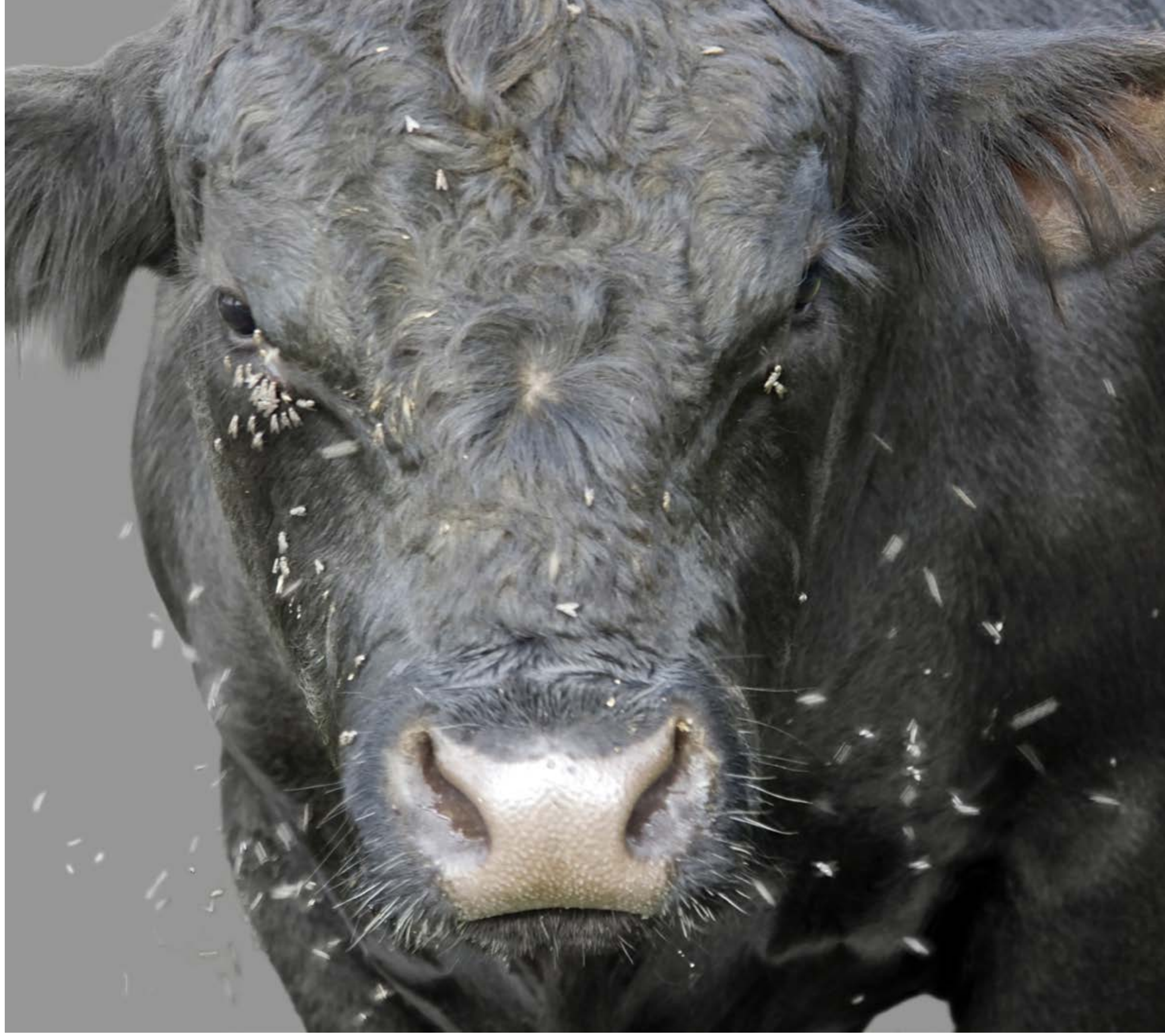
He says the main thing is to establish the bacterium in the population because once flies are infected, three control scenarios open up. While Wolbachia is a maternally transmitted bacterium, through eggs, male flies can still be used to manipulate this.

If a Wolbachia-infected male mates with a healthy female, the eggs will be infertile and so no offspring are born. Conversely, if a healthy male mates with an infected female, the mating will be successful with eggs and offspring produced, but they will be carrying Wolbachia and help to spread it through the buffalo fly population. Dr James says the advantage of this is that it saves researchers having to otherwise breed and release millions of infected or sterile flies.

"But Wolbachia also has a whole lot of other impacts on fly population fitness. We have shown that just the presence of the bacterium can shorten the buffalo flies' lifespan, reduce the number of eggs laid, and the number of pupae that hatch. There are probably also other fitness penalties that we haven't yet identified. If you start to add up all these impacts, that can be a heavy load on survivability.

"And this is where the winter factor comes in. In many areas, the buffalo fly only just hangs on in low numbers through winter, so even Wolbachia's effect on population fitness could be enough to wipe out these populations if the bacterium is deployed strategically."

A second approach is to use Wolbachia to block transmission of the Stephanofilaria nematode transmitted by buffalo flies and associated with the development of buffalo fly lesions on the cattle. Similar to the way that Wolbachia blocks transmission of dengue virus, zika virus and a number of other viruses transmitted by mosquitoes, it has also been shown to block transmission of some nematodes closely related to Stephanofilaria. Spread of Wolbachia through the buffalo fly population could block the nematode and alleviate lesion development.



Buffalo flies Haematobia irritans exigua *(BF) and closely related horn flies* (Haematobia irritans irritans) *(HF) are invasive haematophagous parasites.*

A third option being explored is to breed and release sterile males.

"Again, the idea is to use the sterile males strategically by releasing them into those overwintering areas that are already in a weakened state. This could stop or slow the build-up of buffalo fly in the next season or stop the southerly spread, or even provide the basis of local eradication strategies."

Buffalo flies *Haematobia irritans* exigua (BF) and closely related horn flies (*Haematobia irritans irritans*) (HF) are invasive haematophagous parasites.

Dr James says the challenge now is to improve the consistency and persistence of Wolbachia infection. Since the Wolbachia project started in 2017, researchers have achieved the first big challenge of taking different Wolbachia strains from mosquitoes and also fruit fly and introducing them into a whole new species, the buffalo fly: "Wolbachia has been carried across generations in a number of instances, but we have yet to produce a stably infected strain," he explains.

"But we have reached the stage where we can start finessing the approach. For example, we have a project looking at ways to immunosuppress the fly to favour Wolbachia infection.

"We've built up a reasonable toolbox so I am confident we are close to providing sustainable biological control that will deliver economic animal welfare relief to the northern cattle industry, and save the southern industry from ever having to endure the same burden."

This project is jointly funded by Meat and Livestock Australia, The University of Queensland, and Queensland Department of Agriculture and Fisheries.

Photo of Dr Peter James by Shan Goodwin Farmonline.

A stingless bee (right) and a honey bee (left) side by side on a citrus flower. (Photo: © Dr Tobias Smith, UQ)

Science sweetens native honey health claims

Science has once again validated Indigenous wisdom by identifying a rare, healthy sugar in native stingless bee honey that is not found in any other food.

University of Queensland organic chemist Associate Professor Mary Fletcher said Indigenous peoples had long known that native stingless bee honey had special health properties.

"We tested honey from two Australian native stingless bee species, two in Malaysia and one in Brazil, and found that up to 85 per cent of their sugar is trehalulose, not maltose as previously thought," she said.

Dr Fletcher said trehalulose was a rare sugar with a low glycaemic index (GI), and not found as a major component in any other foods.

"Traditionally, it has been thought that stingless bee honey was good for diabetes, and now we know why – having a lower GI means it takes longer for the sugar to be absorbed into the blood stream, so there is not a spike in glucose that you get from other sugars," Dr Fletcher said.

"Interestingly, trehalulose is also acariogenic, which means it doesn't cause tooth decay."

Dr Fletcher said the findings would strengthen the stingless bee honey market and create new opportunities.

"Stingless bee honey sells now for around $200 per kilogram, which is up there with the price of Manuka and Royal Jelly honey," she said.

"The high commercial value also makes it a risk for substitution, where people could sell other honey as stingless bee honey, or dilute the product.

"But due to this research, we can test for this novel sugar, which will help industry to set a food standard for stingless bee honey.

"People have patented ways of making trehalulose synthetically with enzymes and bacteria, but our research shows stingless bee honey can be used as a wholefood on its own or in other food to get the same health benefits."

The work of Dr Fletcher and the research team has led to a new project funded by AgriFutures Australia and supported by the Australian Native Bee Association.

Working with Dr Natasha Hungerford from QAAFI and Dr Tobias Smith from the School of Biological Sciences, the new project will investigate storage and collection, to optimise the trehalulose content of Australian stingless bee honey.

Stingless bees (Meliponini) occur in most tropical and sub-tropical regions, with more than 500 species across Neotropical, Afrotropical and Indo-Australian regions.

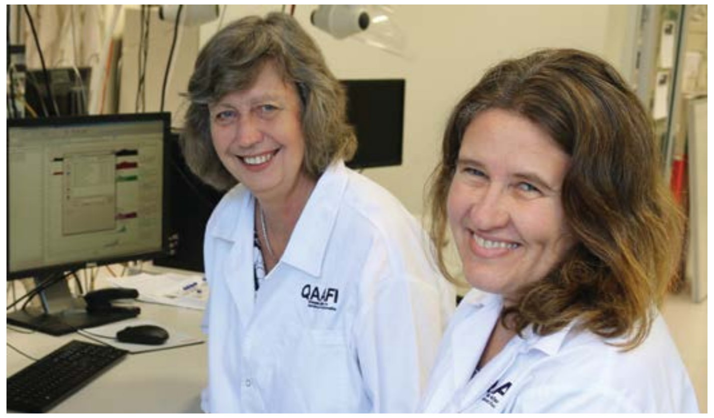
Like the well-known *Apis mellifera* honeybees, stingless bees live in permanent colonies made up of a single queen and the workers, who collect pollen and nectar to feed larvae within the colony.

Dr Fletcher said keeping native stingless bees was gaining in popularity in Australia, for their role as pollinators as well as for their unique honey.

As well as having health benefits, stingless bee honey is valued for its flavour and is in high demand from chefs.

The research by Dr Fletcher and her collaborator Dr Norhasnida Zawawi from the Universiti Putra Malaysia, and colleagues from QAAFI, and School of Chemistry and Molecular Biosciences and Department of Agriculture and Fisheries, is published in Scientific Reports.

The project Optimising bioactive content of Australian stingless bee honey is supported by funding from AgriFutures Australia as part of the AgriFutures Emerging Industries Program.



Professor Mary Fletcher (left) with Dr Natasha Hungerford.

A collaborative culture in animal welfare

Australians are more aware than ever of issues relating to animal welfare, and they are becoming more conscious of the need to care for animals, physically as well as mentally.

There are many different views on animal welfare, so determining what is 'best' for an animal is not always easy. It is this awareness that has highlighted the need for a collective drive towards better understanding for better welfare of animals in Australia.

First created by key Australian universities in 2018, The Animal Welfare Collaborative (TAWC) is facilitating collaboration among a broad network of individuals, companies, and organisations who choose to work together, exchange ideas and information, and support each other in taking practical actions that improve the welfare of animals.

TAWC exists to improve the welfare of all animals under the care of society, including livestock and production animals; animals used in research and teaching; animals used for work, recreation, sport, entertainment, and display; pets and companion animals; and wild animals.

Within the network, independent views are acknowledged, but the primary driver of action is the collective support for TAWC's goal of improving the welfare of animals.

University-based researchers facilitate connections and activities across the network, allowing for evidence-based discussions and open processes that enable anyone in society to participate.

Anyone can be part of TAWC, including members of the public with an interest in animal welfare, businesses and industries that depend on animals, organisations that advocate for, protect, and rescue animals, government bodies that are responsible for animal welfare, and providers of animal welfare education and research.

TAWC encourages anyone with an interest in animal welfare to contribute ideas and join TAWC's ongoing activities, working together to advance the welfare of animals.

Above (left) Professor Bronwyn Harch (left) with Professor Alan Tilbrook at launch of TAWC in 2019.

Sheep grazing.

Genomics drives discovery of low-emission sheep

New research explores a genetic link for high methane-producing sheep by analysing data on gut microbial populations with the animal's genomic information, and measurements of the amount of methane it produces through burping.

Dr Elizabeth Ross *(pictured)* applied this approach to dairy cattle in 2013, predicting high and low methane emitters from rumen microbial profiles – the first time anyone had used microbial populations to predict the host phenotype.

An accurate DNA prediction test for methane production could help farmers produce the same amount of meat and wool from their livestock with less environmental impact.

Researchers have used genomics to accurately predict a sheep's methane output levels.

The work forms part of a multi-disciplinary Australian project to reduce the contribution of livestock to greenhouse gas emissions.

QAAFI research fellow Dr Elizabeth Ross studied sheep methane data collated by the University of New England, in conjunction with genomic markers from the sheep's gut microbiomes to predict methane output.

Genomic prediction is the prediction of total genetic value using genome-wide dense marker maps.

The technology was pioneered by Elizabeth's supervisor, Professor Ben Hayes, Director of the Centre for Animal Science. It is now widely used in livestock and crops to predict future trait outcomes, and is increasingly used in human disease research.

Dr Ross said researchers wanted to be able to tell which sheep produce high levels or low levels of methane, which is a greenhouse gas and also causes a loss of energy from the animal's system.

"Energy lost as methane means that the animals are not using that same energy to grow and produce," she said.

"We used a genomics approach to look at what different species of microbes are in the rumen and also how abundant each one is. "

This approach looks at the entire gut microbial population in the sheep's rumen, and then compares different animals to see if those populations are very similar or very different.

This information is used in conjunction with genomic markers from across the animal's genome to predict how much methane that animal is going to produce.

Dr Ross was able to accurately predict methane output from a population of 99 Merino-cross sheep, based on differences in the genome.

"When we look at the different microbes and the chemicals those microbes produce in the rumen, we can use them to predict which animals will produce high or low levels of methane," she said.

"The work begins to integrate omics data into prediction methodologies and apply its predictive ability to increase our understanding of methane output.

"Integrating genomic, metabolomic and microbiome relationships to predict enteric methane production showed higher accuracy than either method alone."

Dr Ross used data from a parent study conducted by University of New England researcher Victor Hutton Oddy, who collated methane emission data from the 99 sheep using a respiration chamber.

The aim is to create tools that could help farmers produce the same amount of meat and wool from their livestock with less environmental impact.

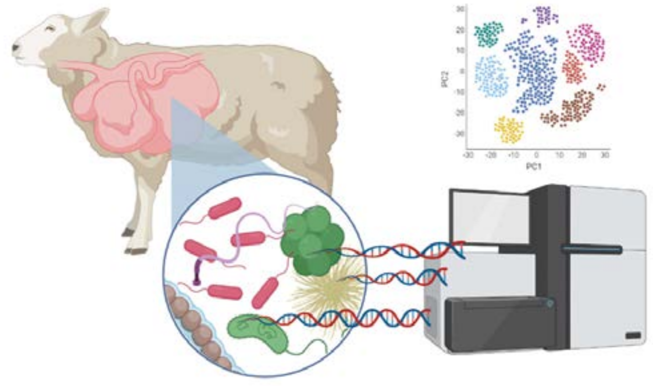
Dr Ross says the work will potentially be used to not only reduce greenhouse gas emissions from Australian livestock – estimated at 71 per cent of total emissions created by the agricultural sector – but also to inform farm practices so that more is produced from the same inputs.

The work was part of the 'Host control of methane emissions from sheep' project, one of four projects coordinated Ruminant Pangenome Project, a national program led by Professor Phil Vercoe at the University of Western Australia (UWA).

The sheep were in a structured population of half-siblings in four families (lambs from four different sires).

They were studied over a three-year period, and their microbiomes and methane output were measured at two different time points.

Dr Ross said when sheep had similar microbial populations, they produced similar amounts of methane.



Populations of microbes in the rumen are studied to identify patterns associated with important traits. Image supplied.

"But sheep's microbial populations can be quite different because it can depend on things like how quickly food moves through the rumen, and different things that might be excreted through, for example, the saliva," she said.

"There is also always the very big effect of diet. If you change the diet, you change the microbes that are growing in the rumen.

"You can manipulate the microbial population in that way – so if you feed animals a diet that reduces methane, the microbes that grow in the rumen will have a similar population structure to a naturally low methane-emitting animal."

The outcomes potentially have far-reaching benefits for greenhouse gas emissions and livestock production.

"If we can identify which animals within a breed naturally produce less methane, we can use those," Dr Ross said.

"That means that for that breed, without compromising any production metrics, we can lower methane emissions because we'll know which ones are naturally producing less methane.

"Those individuals are the ones we want to use because they're producing just as much meat as the other animals in the flock but less methane. So if we breed from them, we can pass on the genetic component."

Dr Ross says a long-term goal of the research is to help farmers identify which sheep are naturally low-methane emitters, so they can make informed decisions about which animals they have on their property.

"There is an inverse relationship between feed efficiency, where animals are converting the energy in their feed into products such as muscle or milk or wool, versus releasing it as methane.

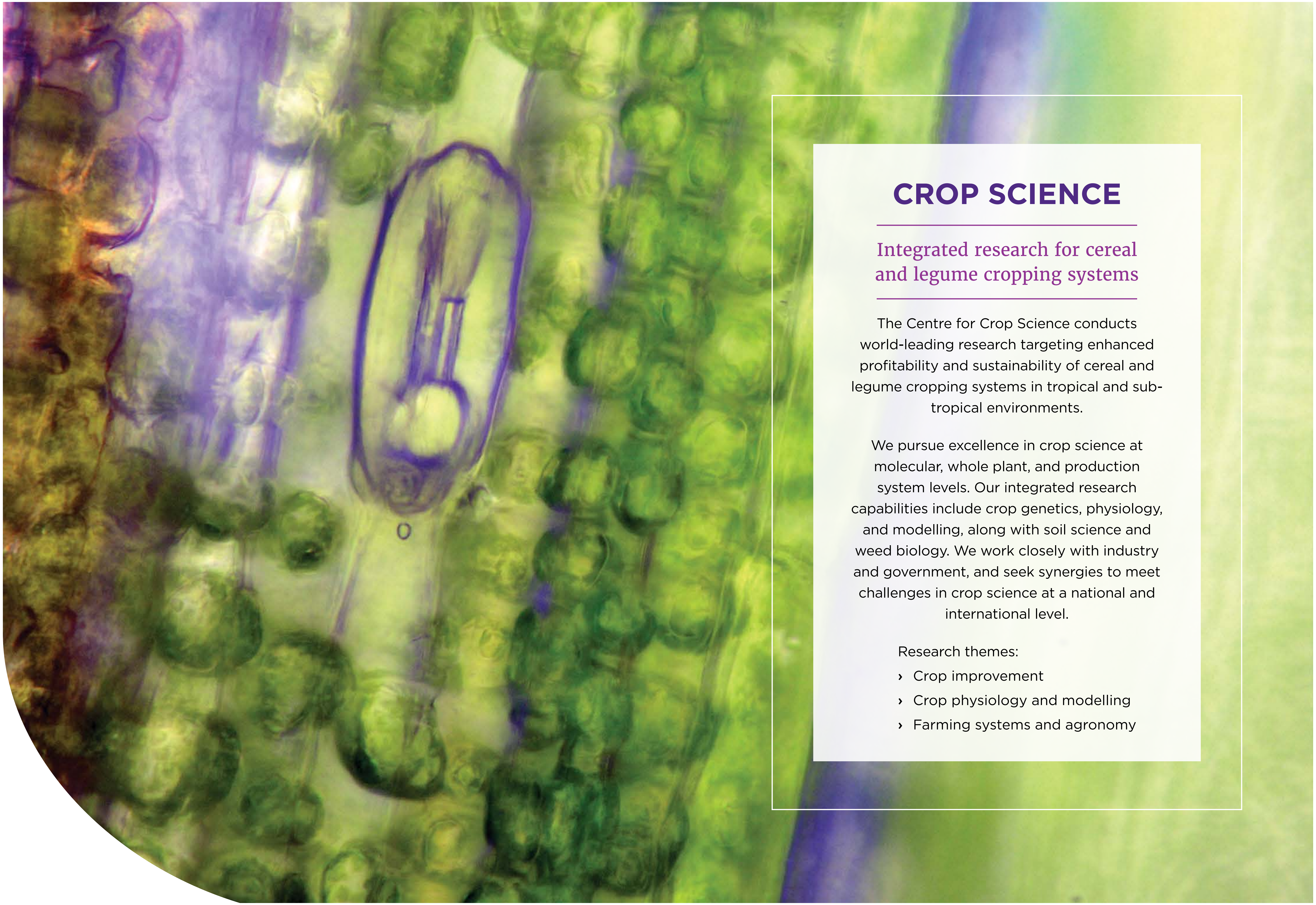
"That energy can either go into the animal, or it can go out of the animal in the form of methane and is lost. It potentially has a really nice advantage where animals can be more efficient and also better for the environment."

She says the methane production predictions were about 20 to 30 per cent accurate, meaning it is 20 per cent of the way to a perfect prediction.

"That is on the lower side, but it's significant in the sense that it was a real difference that we were picking up and it allowed us to identify low-methane emitters. What we hope is to be able to get bigger numbers of animals so that we can improve that accuracy."

The project was a collaboration of researchers from QAAFI, the New South Wales Department of Primary Industries, UNE, CSIRO and UWA.

The work was funded by Meat and Livestock Australia and the Department of Agriculture, Fisheries and Forestry under the Filling the Research Gap program.



CROP SCIENCE

Integrated research for cereal and legume cropping systems

The Centre for Crop Science conducts world-leading research targeting enhanced profitability and sustainability of cereal and legume cropping systems in tropical and sub-tropical environments.

We pursue excellence in crop science at molecular, whole plant, and production system levels. Our integrated research capabilities include crop genetics, physiology, and modelling, along with soil science and weed biology. We work closely with industry and government, and seek synergies to meet challenges in crop science at a national and international level.

Research themes:

- Crop improvement
- Crop physiology and modelling
- Farming systems and agronomy

A genetic solution for sorghum lodging

After decades of collaborative study, University of Queensland sorghum researchers have identified a genetic solution to the problem of sorghum lodging, which affects 10 per cent of sorghum crops every year.

Lodging refers to how the plant stands upright, when carrying high grain yields.

"Lodging is an issue that affects about 10 per cent of Australia's sorghum crops a year, which are valued at $445 million," said Professor David Jordan a Professorial Research Fellow at QAAFI.

Adverse events, such as a dry finish to an otherwise high-yielding season, can lead to 100 per cent crop losses.

"Losing a bumper grain crop because plants fall over is heartbreaking for growers, and undermines efforts to increase production to improve food security," Professor Jordan said.

Sorghum is particularly prone to falling over or 'lodging', but Professor Jordan said scientific breakthroughs point to a genetic solution.

Professor Jordan, working with a team from the Department of Agriculture and Fisheries (DAF) at the Hermitage Research Facility in in Warwick, found that lodging occurs whenever water scarcity forces a halt to photosynthesis.

"This forces the plants to rely on carbohydrates stored in the stems," Professor Jordan said.

"The metabolic shift ultimately weakens the stems, culminating in their death. Pathogens can invade and further weaken stems, causing them to the break."

Environmental conditions that give rise to stem damage and lodging were found to occur in most production regions, but with varying frequency and severity, depending on the degree of water stress.

Doctoral student Xuemin Wang analysed data from 14 growing seasons and found that lodging frequency varies from 0 to 100 per cent, with the most severe lodging (greater than 20 per cent) observed in 2005, 2016 and 2017. The Southern Oscillation Index was shown to explain 29 per cent of the seasonal variation in lodging frequency.

"The study clearly supports a link between lodging incidence and water stress across regions and seasons," Professor Jordan said.

"Our data also found that, despite substantial breeding efforts and turnover of commercial cultivars during the study period, the level of resistance to lodging appears not to have improved."

Genetic mapping

The reason for stagnating genetic gain against lodging was also analysed by the QAAFI team.

The researchers found that traits used to drive up yields also introduced a susceptibility to lodging. An example of such a trait is plant height, which is essential to achieving higher yields but also raises the risk of lodging-inducing stem failure.

"The higher the yield potential of a sorghum hybrid, the more likely it is to suffer from lodging, creating a challenge for breeders trying to improve both traits," Professor Jordan said.

To meet this challenge, scientists sought a full understanding of the genetics that underlie lodging.

The aim was to discern whether genes existed that associate with lodging resistance via mechanisms that would not decrease yields.

This proved to be a successful strategy.

"We undertook one of the largest genome-wide association studies done in sorghum in the world," Professor Jordan said.

Prof David Jordan views sorghum crop at the Gatton Research Facility.

Sorghum lodging for crop at Biloela in Queensland (2019).

Sorghum lodging for crop at Springsure, Central Queensland (2005).

"This study looked at 2308 unique hybrids grown in 17 Australian sorghum trials over three years."

Genetic mapping revealed that lodging is a complex trait in sorghum, with about 213 regions of the genome involved. That means variation in many genes are able to cause variation in lodging characteristics.

"A genome-wide view of the genetics is especially important going forward," Professor Jordan said.

"It means we can discriminate among all the network of lodging-associated genes for those pathways that we can target for improvement without sacrificing yield potential."

Targeted breeding at the cellular level

High on the list of viable candidates is the option to increase stem strength by altering the composition of the molecules used by the plant to assemble the supportive cell wall.

Bolstering disease resistance at the same time would offer additional protection to the stems.

Particularly attractive to researchers are genes involved in the biosynthesis of lignin, which is a woody molecule that adds a lot of strength to plant cell walls.

The research team is now poised to translate these kinds of insights into targeted breeding strategies that stand to directly benefit the Australian sorghum industry.

One approach under consideration involves screening genetically diverse sorghum collections for variation in the lignin biosynthesis genes.

Screening could be accelerated through the use of hyperspectral cameras that use near-infra-red light to measure the lignin content of stems without destroying the plant.

Ultimately, the team wants a strategy that rapidly delivers optimum benefits in growers' paddocks. They know what it takes to deliver beneficial new traits into commercially viable cultivars.

Previously, Queensland sorghum researchers introduced greater drought resistance into Australian cultivars through the transfer of stay-green genes from sorghum sourced from Ethiopia.

Those same stay-green genes are now recognised to have introduced a level of resistance to lodging by delaying photosynthesis shutdown and stem death in response to water scarcity. It is these genetics that retrospectively allowed gains in yield potential in recent years without commensurate increases in lodging.

"We are at the point where we have come as far as we can with the stay-green mechanism for reducing the incidence of lodging," Professor Jordan said.

"By generating the new genetic map, we can now identify new leads for breeding greater lodging resistance into high-yielding sorghum hybrids."

The sorghum core pre-breeding project was funded by the Department of Agriculture and Fisheries (DAF) Queensland, Grains Research and Development Corporation (GRDC), and The University of Queensland (UQ). Field trial support for the project was also given by the sorghum pre-breeding team at Hermitage Research Facility based near Warwick in Queensland.

Xuemin Wang is financially supported by an Australian Government Research Training Program Scholarship and a Centennial Scholarship from UQ.

Investing in sorghum research

Grain sorghum is a major summer crop, produced largely as a feedgrain for the Australian domestic market.

New markets for Australian sorghum are opening up in China for use in fermentation of alcoholic spirit, and in the gluten-free human food market.

Genetics is one of the principal factors contributing to the current upward trend evident in Australian grain sorghum yields.

The Queensland Government, along with the Grains Research and Development Corporation and UQ, supported improvement and innovation in a sorghum pre-breeding program run at Hermitage Research Facility for 20 years.

The cost-benefits of this research mainly stem from yield gains, estimated at 2.1 per cent a year. This estimate is based on Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) data that shows average sorghum yields increased from about 2 to 3.5 tonnes per hectare between 1996 and 2015.

The pre-breeding program has licensed almost 3000 sorghum lines to the international sorghum industry since 1989, which is about 10 times the amount of plant breeding material than in all the other public sorghum breeding programs around the world – combined.

The economic analysis of this investment over this period equates to a cost-benefit of $8.90 for every $1 invested by the research funders.

Gene editing opens faster, cheaper way to introduce new crop traits

CRISPR gene-editing technology has the potential to dramatically increase the number of traits that can be introduced into agricultural crops, far quicker and cheaper than genetically modified (GM) technology has been able to achieve.

In a University of Queensland webinar, 'Good enough to eat', in April 2020, QAAFI's Director of Crop Science Professor Ian Godwin *(pictured)* said only a very small number of GM crops had been approved and adopted in Australian agriculture, but gene editing offered huge potential for a vast array of traits to be made more readily available to Australian growers.

"Because gene-edited crops are not going to be regulated, it means there is not going to be a huge cost to get them to the market," he said.

"The cost of getting them to the market won't be much higher than any standard plant breeding. That means there will be a lot of diverse traits out there."

Professor Godwin said the main reason there was such a small number of GM crops and traits available was the high cost of getting them through regulation.

"For example, if we had a GM sorghum that had higher protein and was more digestible, it would cost in the order of US$50 million to get through all the regulation," he said.

"Hence, most of the GM crops have traits that have already gone through the regulatory process. So (with Bt) and Roundup Ready crops, we have gone through the regulation and it is easier to get a new Roundup Ready crop to market.

"That has led to a terribly small handful of GM crops. There are only 10 crops at the moment that have genetically modified versions. I predict that in 10 years' time there will probably be gene-edited versions of 20 to 30 different crop species and there will be many traits within those species."

Simple technique

Godwin said one of the main attractions of gene editing was that it was a relatively simple technique that opened up new opportunities for plant breeders and seed companies.

"Anyone who can do plant tissue culture and basic transformation can do gene editing," he said.

"The ultimate in democratisation is that, at the moment, the way we do gene editing requires tissue culture, but there are evolving techniques where you can undertake gene editing in the glass house, potentially by spraying the enzyme and RNA onto the plant in such a way it gets into the growing point of the plant.

"If plant scientists can deliver that technology, it means gene editing basically becomes a plant breeding tool available to all plant breeding companies."

Non-viable seed production

Responding to concerns that some proprietary GM crops did not produce viable seed, forcing farmers to buy new seed every year, Professor Godwin said there were many myths surrounding the motives of companies applying that constraint.

"It's a myth that Monsanto developed it and called it Terminator technology. It was actually developed by the United States Department of Agriculture," he said.

"It wasn't really about making people buy the seed every year; it was more about ensuring that whatever trait was put into a crop won't pass on to the next generation because that generation can't make viable seeds.

"If you can't regrow the seed, it also means there is no escape of the genetic material from those grains."

Professor Godwin said it was often to the farmer's advantage to start afresh with quality-assured seed.

"It is not so much the case in subsistence agriculture, but in the Western world where we are trying to produce food as cleanly and efficiently as possible and maximise yield, most farmers will buy their seed every year because they know it will be good quality seed that comes with a germination percentage," he said.

"If you keep the seed yourself and plant it and it's got only 30 per cent germination, you are not going to get a crop and you have only yourself to blame because you didn't have good quality seed to start with."

Sustainable production

Professor Godwin said there were many examples throughout the world where GM crops had allowed viable, sustainable agricultural production that otherwise wouldn't have been possible.

"Even though it is publicly cited that no-one in Europe grows GM crops, there is quite a bit of Bt, insect-resistant maize grown in Spain. The reason is that otherwise they wouldn't be able to grow it because resistance to insecticide is so bad. They are growing insect-resistant crops because they have to," he said.

"We know that from a productivity and environmental point of view if all jurisdictions in the world had access to the technology, farmer profitability would go up, but more importantly, sustainability would go up.

"Despite the marketing, things that are calling themselves organic are not the most sustainable because if you have to double the food production area to get the same amount of production, what is the outcome? It means grasslands and forests have to be cleared to turn into agriculture."

Dr Karen Massel © University of Queensland.

Hotter, drier, CRISPR

Gene editing technology will play a vital role in climate-proofing future crops to protect global food supplies.

Biotechnologist Dr Karen Massel has published a review of gene-editing technologies, such as CRISPR-Cas9, to safeguard food security in farming systems under stress from extreme and variable climate conditions.

"Farmers have been manipulating the DNA of plants using conventional breeding technologies for millennia, and now with new gene-editing technologies, we can do this with unprecedented safety, precision and speed," Dr Massel said.

"This type of gene editing mimics the way cells repair in nature."

Her review recommended integrating CRISPR-Cas9 genome editing into modern breeding programs for crop improvement in cereals.

Energy-rich cereal crops, such as wheat, rice, maize and sorghum, provide two-thirds of the world's food energy intake.

"Just 15 plant crops provide 90 per cent of the world's food calories," Dr Massel said.

"It's a race between a changing climate and plant breeders' ability to produce crops with genetic resilience that grow well in adverse conditions and have enriched nutritional qualities.

"The problem is that it takes too long for breeders to detect and make that genetic diversity available to farmers, with a breeding cycle averaging about 15 years for cereal crops.

"Plus CRISPR allows us to do things we can't do through conventional breeding in terms of generating novel diversity and improving breeding for desirable traits."

"In sorghum, we edited the plant's genes to unlock the digestibility level of the available protein and to boost its nutritional value for humans and livestock," she said.

"We've also used gene editing to modify the canopy architecture and root architecture of both sorghum and barley to improve water-use efficiency."

Dr Massel's research also compared the different genome sequences of cereals – including wild variants and ancestors of modern cereals – to differences in crop performance in different climates and under different kinds of stresses.

"Wild varieties of production crops serve as a reservoir of genetic diversity, which is especially valuable when it comes to climate resilience," she said.

"We are looking for genes or gene networks that will improve resilience in adverse growing climates.

"Once a viable gene variant is identified, the trick is to re-create it directly in high-performing cultivated crops without disrupting the delicate balance of genetics related to production traits.

"These kinds of changes can be so subtle that they are indistinguishable from the naturally occurring variants that inspired them."

In 2019, Australia's Office of the Gene Technology Regulator deregulated gene editing, differentiating it from genetically modified organism (GMO) technology.

Gene-edited crops are not yet grown in Australia, but biosecurity and safety risk assessments of the technology are currently being undertaken.

This research is funded by an Australian Research Council Discovery grant with support from the Queensland Department of Agriculture and Fisheries and The University of Queensland.

De-risking broadacre cropping options for northern Queensland

Northern Australia is new to dryland cropping, and the need to identify best crop and management options that bridge gaps between present and achievable yields are highly relevant.

Farmers benefit from having a better understanding of the best combinations of agronomy and cultivars of cereals to the growing conditions and markets of northern Australia. Agribusinesses benefit from increasing the efficiency of crop improvement programs for northern Australia, a higher demand for agricultural inputs, and by an improved availability of locally developed technical information.

Results from the first year of trials in this project, led by Professor Daniel Rodriguez, across four sites showed that:

- New experimental red, white and high-digestibility grain sorghum hybrids produced grain yields that were similar or higher than the yield of well-known commercial check hybrids.
- The experimental high-digestibility sorghums produced approximately 30 per cent digestible higher energy (MJ/ha) than the commercial hybrids.
- Soil spatial variability remains a significant challenge in the analysis of on-farm replicated experimental data.

A second year of trials is underway.

'Prestwood Station' in Far North Queensland is one of the sites participating in the CRCNA and GRDC 'De-risking broadacre cropping options for Northern Queensland' project. From left to right: Professor Joe Eyre, (QAAFI); growers Beverley and Reg Pedracini; Laura Miller, project participant Northern Gulf Resource Management; and QAAFI's Professor Daniel Rodriguez. Photo: supplied

Northern Australia has potential to become a 'tropical rice powerhouse'

The *Situational Analysis for Developing a Rice Industry in Northern Australia* report outlines the critical next steps for the development of a profitable, sustainable and socially beneficial northern Australian rice industry.

Global rice consumption is expected to rise by 13 per cent by 2027. The market for Australian rice of 1,700,000 tonnes for export and 130,000 tonnes for domestic consumption vastly exceeds the amount of rice that is currently produced in Australia (recent average of 600,000 to 800,000 tonnes, but less than 55,000 tonnes in 2019).

The advantages of producing rice in northern Australia include: a suitable production temperature; water and land availability (e.g., Burdekin, Tully, Atherton Tableland, Cape York and the Gulf); and the capacity to grow high-value aromatic rice varieties. Native Australian rices also naturally grow in various locations across northern Australia.

With sufficient resourcing and guidance, a northern Australian rice industry has great potential to:

- Conservatively produce well over 100,000 metric tonnes of rice per year within 6 years
- Deliver $45 million to growers in North Queensland alone within 5-6 years, which is similarly scalable to other northern Australian regions
- Achieve yields of 10 tonnes/ha, or greater, through aerobic cropping, which would minimise water and nitrogen use
- Provide a unique and profitable rotation crop option for northern Australian farmers, which could support other agriculture industries, de-risk current rotations and provide additional income streams
- Achieve prices of up to $200/kg for wild harvested native rice
- Create jobs in northern Australia (e.g., approximately 70 jobs at rice mills in North Queensland within 6 years)
- Create positive impact on community through capacity building and new regional opportunities.

Pictured: Prof Robert Henry

FNQ miller and growers team up to shake up local sugarcane industry

The $1.3 million, three-year suitable sugarcane to diversify income and add value project is focused on boosting tonnages and extracting more value from feedstock delivered to Far Northern Milling's Mossman mill in an effort to support the long-term prosperity of local growers, the mill and the broader far north Queensland economy.

Project lead Professor Frederik Botha *(pictured)* from the University of Queensland's Queensland Alliance for Agriculture and Food Innovation (QAAFI) said crop trials of commercial, near commercial and energy cane varieties have already started on the Tablelands and in Mossman. Crop trials will also include the testing of several sorghum varieties as possible supplementary biomass inputs for Mossman mill.

"Initially, we are focusing on identifying those cane and sorghum varieties which are the best biomass producers, meaning they are energy dense, with good foliage, high fibre and sugar levels. This would help alleviate the current feedstock shortfall at the Mossman mill. However, these high biomass varieties will otnly be useful if they have sucrose and fibre levels that will allow processing with the current milling infrastructure," he said.

"We will then take a close look at the chemical composition of these varieties examining the whole plant from the leaves, trash and the stalks, to determine the best varieties and how these components could be further developed into commercially viable products to boost income streams for growers and millers."

The final stage of the research will be to develop recommendations and business cases for producers and Far Northern Milling to outline how they can develop sustainable farming systems to support a new approach to sugarcane farming.

Mossman grower and trial participant Don Murday said exploring diversification options is crucial to the long-term viability of the region's mill and sugarcane industry.

"Biomass has long been touted as a quality, renewable feedstock source for mills and a value-add for growers.

"As growers we need to invest in our future and ensure we can maximise the value of our crops.

"Moving to an integrated, rotational production system which includes traditional sugarcane varieties grown alongside high energy canes or sorghum, means we could deliver new, sustainable income streams for growers and millers," he said.

Far Northern Milling's General Manager Peter Dibella said the CRCNA collaboration will support the cooperative's broader vision to locate a suite of environmentally sustainable bio-projects value adding to the mill's feedstock (syrup, sugar, bagasse, and molasses), as part of a Daintree bio-precinct.

"We need to look outside of the box if we are going to transform the sugarcane industry and provide a pathway for long-term, economic growth for this region," Mr Dibella said.

Given the location of the Mossman production areas in the Great Barrier Reef catchment, environmental considerations are always front of mind. To this end, Professor Botha said efforts to increase biomass should not be driven by more nutrient input, or at the expense of soil health.

"Our approach is to cast the net wide and screen the diverse range of sugarcane genotypes already bred by SRA but not selected for commercial release. This project will select those varieties which can deliver in the conditions specific to the Mossman mill region and the increased biomass requirements of the mill," he said.

SRA Executive Manager for Variety Development Dr Jason Eglinton said the project is an ideal platform to test a broad range of types of sugarcane for potential future products.

CRCNA CEO Jed Matz said the project will demonstrate the possibilities available to sugarcane growers in an economically and environmentally sustainable way.

Professor Botha said the project team will hold a grower field day and project update early in 2021.

This research is funded by the CRCNA, The University for Queensland, Far Northern Milling Pty Ltd, Sugar Research Australia and supported by the Queensland Department of Agriculture and Fisheries.

Future food and the art of plant mechanics

Better understanding plants' complex environmental and food-producing roles is the focus of a new global research program being led by The University of Queensland, in which QAAFI researchers will play a leading role.

The University of Queensland is spearheading an ambitious global research program to fundamentally change the approach to plant breeding to lift the performance of food crops and the sustainability of plants in nature.

The intention, under the recently created Australian Research Council Centre of Excellence for Plant Success in Nature and Agriculture, is to provide a platform on which specialists in different aspects of plant genetics and physiology can combine their knowledge.

The centre's director, Professor Christine Beveridge *(pictured)* FAA from UQ's School of Biological Sciences, explains that while a lot is known about the different genetic components of plants and their agronomy, it is specialised and disconnected. "We need to assemble this so that we know much more about how all the different parts of a plant work and fit together as a whole plant system.

"The knowledge exists," she says, "but spread across different plants, crops, industries and environments. For example, an avocado looks very different to a cereal, but they have much the same genes controlling flowering time. It's the same for many plants and why the whole plant kingdom is a tremendous genetic resource."

The centre will bring together specialists from 13 academic and industry partner organisations from Australia, Europe, Asia, the USA and Canada. The objective is to apply 'groupthinking' to plant breeding obstacles that are limiting yields and ecosystem sustainability.

Professor Beveridge says the objective is to increase the genetic rate of gain needed to keep crop yields in step with the rising world population – projected to rise by 25 per cent over the next 30 years – as well as to enhance sustainability of plant life generally.

Exhausted trinity

Professor Beveridge illustrates the scale of the untapped genetic potential in plants by pointing to the fact that two-thirds of all the calories provided by plants for human consumption come from just three species – maize (corn), wheat and rice.

She says the difficult goal of doubling the genetic rate of gain for these food staples from one per cent a year to two per cent could become more achievable by tapping the genetics of other plants – both cultivated and wild.

"That's why we have to bring together all we know across different plant science disciplines and to see plants as interconnected systems at the genetic, physiological and crop levels.

Federal Minister for Education Dan Tehan MP and UQ's Professor Christine Beveridge.

"Learning more about how all elements of a plant function and fit together then puts us in a much better position to more accurately predict what would happen, and what the benefits would be, if we modify any part of those systems."

Professor Beveridge's own investigations into what determines tillering in sorghum is an example. She explains how for all plants, branching and tillering is a fundamental system involving light energy, nutrients and hormones, and the genes that regulate these components.

Working with garden pea and Arabidopsis, Professor Beveridge's team has identified the relevant genes in these plants and built a model that shows, diagrammatically, how tillering works.

They are now working to extrapolate this to sorghum, an important commercial crop. Tillering can have a big impact on crop yields but is strongly influenced by climate variability.

"We know very little at the genetic/mechanistic level about what drives tillering in sorghum," Professor Beveridge says. "But by studying the system at work in pea and Arabidopsis we can see, first, if any genes correlate with what we know in sorghum." If there are matches, she says, they can use their knowledge of peas to create a model to identify how genetic changes in sorghum might affect tillering.

Bridging model

"It is all about testing a model we already have for one plant species and seeing if we can use it to add value to another – in this case, improved prediction of gene behaviour in sorghum phenotypes," Professor Beveridge says.

This could be important for sorghum growers because the number of tillers can affect yield positively or negatively, depending on conditions. Tillering occurring too early, for example, can lead to water and nutrients being used up before the tillers are productive.

"So if you want to breed a sorghum variety for a particular environment, you need some genetic control over tillering," she says.

"But because phenotypes are so responsive to environment, the genetics are hard to study because the environmental variation is so huge. However, if you know that response to environmental variation is due to tillers and nitrogen use, and you know how sugars (the product of photosynthesis) and nitrogen (including fertilisers) affect gene regulation, then you can understand why some genetic differences are active in one environment and not in another.

"You can see why this can get messy, but if you have a guiding model, albeit from another plant species, you can proceed with more certainty in breeding for particular environmental conditions. One of the objectives for sorghum is to breed a phenotype that is more robust and productive across a wide range of conditions – blunting the plant's response to unfavourable conditions and enhancing its response to favourable conditions."

Professor Beveridge says other crop traits that are not well understood at a genetic level include responses to biotic stresses, such as high temperature and low moisture – something that native plants in natural systems have honed through their evolution.

"So it may be the models we can use for better understanding and applying improved climate resilience can come from native plants. Nature has come up with countless solutions for biotic stresses. What can we learn about these systems, and how well we have applied these to our development of crops? After all, some of our breeding decisions were made several thousand years ago, and we are still largely stuck with those decisions."

It is this sort of capability that the Centre of Excellence has been charged with developing.

"It's that layer of mechanistic understanding in between genes and phenotype. There's always this interaction between genes, the environment and farm management that affects breeding and it's the genes-by-environment interaction where everyone comes unstuck because we really don't know what that is."

The human challenge

The Australian Government announced funding for the centre at the end of 2019 and there is mounting anticipation as it was established this year. However, Professor Beveridge has a more immediate, human challenge.

The centre will be assembling specialists and postgraduate students from a range of scientific disciplines and backgrounds, and for whom 'groupthink' will be a challenge in itself.

"Research is competitive, and we have to find a way to make it inclusive," says Professor Beveridge. "We have to agree on what advances need to be made, how we approach this, determine the data management and infrastructure needed to support a collaborative engagement, and even the language to use. Ecologists and geneticists, for example, have very different ways of explaining what they do.

"We are setting out to answer some very big questions, and to achieve this we have to be able to respect the research of people who use different yardsticks. For example, if I measure success based on whether I can demonstrate if a gene has a particular molecular function, am I going to give equal weight to the argument of an ecologist who believes a particular plant/environment relationship is the crucial factor? We all may need to learn more and judge less.

"It is going to be interesting – not only a scientific challenge, but also a paradigm shift in the way plant science is done."

Awnless barnyard grass.

Stacking the odds against awnless barnyard grass

In a recent random survey of summer-growing weeds in the northern grains region, 36 per cent of awnless barnyard grass (*Echinochloa colona*) populations proved resistant to glyphosate.

Through a focused effort to better understand this problematic weed, GRDC invested in a series of studies on various aspects of its ecology. This work was done by QAAFI weed researchers, led by Professor Bhagirath Chauhan *(pictured)* at the Gatton campus.

"Awnless barnyard grass is one of the top three most problematic weeds of summer crops and fallows in Australia," Professor Chauhan said.

"Our studies looked at environmental and cultural effects on germination, the impact of crop competition and early weed control, seed retention at harvest, and the effect of low rates of glyphosate."

These studies confirmed that awnless barnyard grass can emerge in spring, summer and autumn in Queensland, with temperature being the main driver of seed germination.

"Germination is rapid for seed exposed to the light on the soil surface, as in no-till summer fallows," he said.

"As the temperature increases, seed buried up to eight centimetres below the surface can also germinate. Covering the soil with crop residue suppressed germination by about 20 per cent, from 70 per cent without cover down to 47 per cent with sorghum trash."

To run down the seedbank of awnless barnyard grass, whether glyphosate resistant or not, requires two to three years of no recruitment through 'seed rain'.

Strategic tillage is useful only if the seed bank is buried to a depth of more than 8 cm and then not disturbed again for many years because the seed will persist for longer than two years once buried.

"The best way to reduce seed production in this weed is to grow competitive crops in summer and to focus on controlling weeds for the first two weeks after crop emergence," Professor Chauhan said.

"Both mungbean and sorghum crops can significantly suppress awnless barnyard grass growth and reduce the quantity of seed set over the warmer months."

Awnless barnyard grass produces 4000 seeds per plant when emergence is with the crop, 1000 seeds per plant when emergence is two weeks later, and less than 100 seeds per plant when emergence is four and six weeks after crop emergence.

"This shows the importance of early weed control – even in widely spaced sorghum," Professor Chauhan said.

The random weed survey indicated that all populations, whether resistant to glyphosate or not, were susceptible to propaquizafop, clethodim and imazapic, providing some herbicide options for growers to achieve early weed control.

In both resistant and susceptible biotypes, very low rates of glyphosate were shown to stimulate growth. This is known as the 'hormesis phenomenon', where a stress can stimulate a positive response.

Plants treated with glyphosate at active ingredient rates of 2.5 to 40 grams/hectare grew taller and produced more leaves, tillers, inflorescences, and seeds than the control treatment.

These rates are far lower than label rates for awnless barnyard grass, and demonstrate the importance of accurate mixing and application of herbicides to ensure lethal rates are applied.

These studies have demonstrated that glyphosate resistance in awnless barnyard grass does not confer any advantage or disadvantage over susceptible biotypes.

The recommendation is to treat all populations as resistant to glyphosate.

Breeding with an eye on genes for paddocks

The cutting-edge technology that produced America's high-yielding, drought-tolerant AQUAmax maize hybrids is being adapted for use in Australian grain breeding programs.

The method works where other breeding technologies struggle because it can better account for the complex interactions that occur between genes (G), the environment (E), and crop management (M) – the so-called GxExM effect.

The new framework is called prediction-based crop breeding, and its development owes a great deal to a collaboration between The University of Queensland and DuPont Pioneer that began in the 1990s.

The University's Professor Mark Cooper played a central role when he transferred to DuPont Pioneer to push the technology's development and its application to maize breeding. That effort culminated in the release of the popular AQUAmax hybrids.

In 2018, Professor Cooper returned to UQ to test whether prediction-based breeding can close yield gaps for grains grown in Australia. The initiative has important implications because Australia is subject to some of the world's most extreme environmental variability and, therefore, some of the most intense GxExM interactions.

This work is now underway through strategic investments at UQ and GRDC. The work will be developed further as part of the new Australian Research Council Centre of Excellence for Plant Success in Nature and Agriculture, where Professor Mark Cooper serves as deputy director.

"Accounting for GxExM interactions is central to our goal of helping to close gaps between realised and potential yield," Dr Cooper. "So, a key interest at the Centre of Excellence is developing predictive methodologies that can deal with genes operating in networks and interacting across different developmental processes and environments."

As part of this initiative, a new project got underway in 2020 to use sorghum as a proof-of-concept crop that will lead the way in applying the technology to Australian crops by exploiting advances made by the Centre of Excellence.

The sorghum project was made possible through GRDC investment and is run by Dr Owen Powell *(pictured)*, who transferred to UQ from the Roslin Institute in Scotland.

"The exciting part is that any advance will drive additional capability for other crops," Professor Cooper says. "So, sorghum is the first iteration. Like many new technologies, our intent is to refine and improve on the first generation."

Sorghum leads the way

Dr Powell's background is well suited when it comes to applications of novel predictive methods.

At the Roslin Institute, located at the University of Edinburgh, he created computer simulations to test the effectiveness of different methods in use at the institute to improve yields in both livestock and hybrid crops.

This included genomic selection, a method based on whole-genome analysis using thousands of DNA markers. By crunching huge amounts of genomic data against performance data from field trials, associations are made that reveal the best bits of DNA to bring together to improve on past varieties.

With the availability of genotyping data of sorghum lines from the work of UQ's Dr Emma Mace and trait phenotyping from field experiments, genomic selection technology has already been applied to sorghum at the University. This took place within the pre-breeding program headed by Professor David Jordan.

The new project, however, will push past that existing capability: "What's interesting about the new sorghum project is that genomic selection forms just one of two components used to make the predictions about the best arrangement of genes needed to improve crop performance," Dr Powell says.

"The second component is the APSIM (Agricultural Production Systems sIMulator) crop growth models developed at UQ by Professor Graeme Hammer and his team that simulate impacts on crops from environmental causes."

The inclusion of crop growth modelling, however, meant that the algorithms needed to be adapted for different crop types, because differences in biology between crops matter with prediction-based breeding.

For example, Dr Powell has started working on tillering in sorghum, which was not an element of the maize crop models but is a key piece of biology in sorghum. "That has a significant impact in GxExM interactions," Dr Powell says. "So, we're trying to understand how strong an influence tillering, in combination with other traits, will have on predicting crop performance and yield.

"However, once the two modelling frameworks – genomic and crop growth – are integrated and adapted to specific crops, the result is a game-changing gain in unique insights about genotype fitness against real-life conditions in the paddock".

Importantly, this approach is much faster than traditional breeding, and it also results in a blueprint that outlines how to bring together optimal gene combinations. As such, the technology stands to accelerate the breeding process.

"It's ultimately about getting the right variety into the right paddock for the right market," Professor Cooper says.

That objective makes GRDC's investment in Dr Powell and the sorghum project one that is foundational to making an important step-change in breeding capability.

Improvement is possible

"No-one at the university yet knows how much extra yield or yield resilience is possible using prediction-based crop breeding. What the researchers do know is that the method being applied has a track record of successfully accounting for GxExM interactions".

That conclusion is supported by studies published by Professor Cooper. In one such work, he and his US team examined impacts from droughts that the US maize industry considered impossible to anticipate.

When the analysis was made using Professor Cooper's maize-adapted algorithms, the modelling accurately predicted the impacts of standout drought events and did so despite these events being excluded from the software's training dataset.

"Given the larger GxExM influence in Australia, it's possible we may see even more upward potential from applying these predictive frameworks here in Australia," Professor Cooper said.

This article was published in GRDC GroundCover, *Nov-Dec 2020.*

Designer root systems to maintain durum wheat yields in drought

To help meet strong international demand for Australia's premium durum wheat, new research has identified genetic solutions to maintain yields during drought.

Queensland research has identified two genes that improve durum wheat yields under drought conditions. The research focuses on the architecture of plant roots and how it contributes to yield stability.

QAAFI's Dr Samir Alahmad *(pictured)* discovered the genes while investigating the traits that durum wheat uses to survive in water-limited conditions.

Dr Alahmad is a previous recipient of Monsanto's Beachell-Borlaug International Scholarship. His current research is part of a postdoctoral fellowship funded by the Grains Research and Development Corporation.

"In dry seasons like 2018 and 2019, farmers suffered significant losses due to reduced grain quality and yield," Dr Alahmad says.

Dr Alahmad holds one of the new experimental lines with diverse root traits. The new lines will be evaluated in 2021 to determine the value of the root traits to support yield in key durum-growing regions. Photo taken at the Queensland Department of Agriculture.

Stabilising yields and quality for the crop in a variable climate is an ongoing challenge for growers, while maintaining supply to international markets. More than 80 per cent of Australian durum wheat exports go to Italy, where it is used for pasta production.

The first step in Dr Alahmad's research was establishing links with durum breeder Dr Filippo Bassi at the International Center for Agricultural Research in Dry Areas (ICARDA) to source elite durum lines that were originally bred for very dry conditions in Syria.

Collaborating with Professor Jason Able at the University of Adelaide, Dr Alahmad then crossed the ICARDA lines with the leading Australian durum wheats DBA Aurora and Jandaroi, subsequently developing a large experimental population to study their traits.

"You need six generations to develop genetically stable lines that are suitable for evaluation," Dr Alahmad says. "I used speed-breeding technology, which involves growing plants under optimal light and temperature conditions, to reduce generation time, and refined the population in just one year."

The next step was to study the durum wheat population for root growth angle using transparent garden pots.

Dr Alahmad matched this information with DNA marker data to perform a genome-wide association analysis. The result was the discovery of a major gene located on chromosome 6A in durum wheat.

Over the following two seasons, he set up field trials in Queensland, South Australia and Morocco to better understand the value of the gene in improving yields under different drought conditions.

"We found there was an association between the root angle gene and grain yield," he says. "In Queensland, root angle appeared to be important for maximising the length of the grain-filling period."

In another genome-wide association analysis, the location of the gene responsible for high-root biomass was identified on chromosome 6B.

"One of the most exciting aspects of the research was discovering that combining the root angle and root biomass qualitative trait loci resulted in a yield benefit of up to 0.9 tonnes per hectare under drought conditions," he says.

However, more insight is needed to determine how much root branching is beneficial at different soil depths to sustain grain yields in different environments. Another challenge is understanding the complex interactions between root and canopy traits that influence the timing of water use.

Now, Dr Alahmad's postdoctoral research is focused on developing elite durum wheat lines with similar above-ground traits that comprise different root configurations.

"These materials will enable us to more precisely determine the role of root traits to support yield under different drought scenarios."

During 2020, seed of the elite lines with diverse root traits was bulked up at Hermitage Research Station, Warwick, in Queensland. In 2021, field trials will be set up in Queensland and South Australia.

To take the research to the next level, Dr Alahmad is using unmanned aerial vehicles (UAV) to look at the effect of above-ground traits on drought tolerance.

"We will use this knowledge about the above-ground traits to better understand the value of root traits and the link between root and shoot dynamics," he says.

"We want to help wheat breeders design future crops for farmers that provide more stable yields across seasons despite variable rainfall.

"In the next 12 months, we will try to understand the traits that sustain grain yield in different seasons."

This research is funded by the Grains Research and Development Corporation, Queensland Department of Agriculture and Fisheries and The University of Queensland.

Source: Originally published in GRDC's GroundCover *Issue 151, March-April 2021, Written by Nicole Baxter*

Durum wheat field.

Root system architecture for durum variety DBA Aurora (left) versus an experimental line carrying the gene for narrow root angle. (Photo: Lee Hickey ©QAAFI)

HORTICULTURAL SCIENCE

Driving innovation and industry adoption

The Centre for Horticultural Science delivers improvements to productivity, profitability and sustainability of horticulture industries.

Our world-class researchers drive innovation and industry adoption to increase the competitiveness of Australia's horticultural industries globally.

We work in close collaboration with government, industry and growers to boost innovation, productivity and economic growth.

Research themes:

- Horticulture crop breeding and agronomy
- Plant protection
- Emerging technologies

Chris O'Brien cryo-freezes avocado shoot-tips.

Professor Neena Mitter and Chris O'Brien with tissue-cultured avocado shoot-tips.

Healthy avocado plants recovered from cryopreservation.

Putting a future avocado apocalypse on ice

The supply of smashed 'avo' is secure for generations after world-first research cryopreserved the tips of avocado shoots and then revived them to create healthy plants.

The University of Queensland PhD student Chris O'Brien has developed the first critical steps to create a cryopreservation protocol for avocado that had never been achieved until now, despite more than 40 years of research.

"The aim is to preserve important avocado cultivars and key genetic traits from possible destruction by threats like bushfires, pests and disease such as laurel wilt – a fungus that has the capacity to wipe out all the avocado germplasm in Florida," Mr O'Brien said.

"Liquid nitrogen does not require any electricity to maintain its temperature, so by successfully freezing avocado germplasm, it's an effective way of preserving clonal plant material for an indefinite period."

Cryopreservation is the technology used to freeze human biological material, such as sperm and eggs, at minus 196 degrees Celsius, and has been used to freeze other plants, such as bananas, grape vines and apple.

Mr O'Brien has been working with UQ Centre for Horticultural Science's Professor Neena Mitter and Dr Raquel Folgado from The Huntington Library, Art Museum, and Botanical Gardens in California to perfect the technique.

He used clonal shoot-tip material developed from tissue culture propagation technology, which enables up to 500 true-to-type plants to grow from a single shoot-tip.

"At first, I was just recovering brown mush after freezing the avocado tips," Mr O'Brien said.

"There was no protocol so I experimented with priming the tips with Vitamin C, and used other pre-treatments like sucrose and low temperature to prepare the cells – it was a question of trial and error to get the optimal mixture and correct time points."

The avocado shoot-tips are placed on an aluminium foil strip, which allows for ultra-fast cooling and rewarming, then placed into a 'cryotube' before being stored in liquid nitrogen.

The frozen shoot-tips can be revived in a petri dish containing a sucrose mixture to rehydrate.

"It takes about 20 minutes to recover them," Mr O'Brien said.

"In about two months, they have new leaves and are ready for rooting before beginning a life in the orchard."

He has achieved 80 per cent success in regrowing frozen Reed avocado plants, and 60 per cent with the Velvick cultivar.

Eighty revived avocado plants are now growing in a UQ glasshouse.

The recovered trees will be monitored for flowering times and fruit quality, with field trials planned with collaborators at Anderson Horticulture.

Professor Mitter said this was the first time the plants had experienced life outside the laboratory.

"I suppose you could say they are space-age avocados – ready to be cryo-frozen and shipped to Mars when human flight becomes possible," she said.

"But it is really about protecting the world's avocado supplies here on earth and ensuring we meet the demand of current and future generations for their smashed 'avo' on toast."

Banana disease research in Costa Rica strengthens Australia's biosecurity

Ms Jane Ray, a PhD Candidate at The University of Queensland, travelled to Costa Rica as part of a project to identify and manage bacterial wilt diseases in bananas after being awarded a Crawford Fund Student Award by the Crawford Fund's Northern Territory Committee. She was supported in-country by the University of Costa Rica.

Bananas are susceptible to three important bacterial wilt diseases that reduce productivity and quality.

These diseases are Moko, blood disease, and banana Xanthomonas wilt, and they all cause similar symptoms of leaf wilting, vascular discoloration, and fruits that remain green on the outside with rotten, discoloured inedible pulp. These diseases are absent from Australia and are of concern to the Australian banana industry.

"Our findings during this project are of value to the Australian banana industry which has a farmgate value of $600 million. These lethal bacterial wilts are exotic to Australia and are listed as high-priority pests in the banana industry biosecurity plan. An incursion would likely result in a costly eradication program, while the establishment of Moko in Queensland alone has been estimated to cost the industry $100 million," said Ms Ray.

Biosecurity is fundamental to the success of future banana production in the Northern Territory, an industry that has already eradicated banana freckle a few years ago.

Moko disease originates from South and Central America, and has also been recorded in the Caribbean Islands, the Philippines and Malaysia, whilst banana blood disease originates from Indonesia.

"Blood disease is an emerging threat to banana production in Southeast Asia and beyond, and is the topic of my PhD research," said Ms Ray.

"This Crawford Fund Student Award project provided a unique opportunity for me to visit Dr Luis Gómez Alpizar from the University of Costa Rica to see Moko disease in the field for the first time," she said.

"In Costa Rica, we visited banana plantations, inspected Moko eradication sites, collected samples of symptomatic banana plants, isolated the bacterium causing Moko, examined cultural morphology, and extracted DNA of the pathogen. The National Banana Corporation of Costa Rica (Corbana) also provided DNA from their Moko culture collections. The DNA returned to Australia was used to validate the molecular diagnostics for both Moko and blood disease," said Ms Ray.

"Gaining an understanding of methods used in Costa Rica to manage the disease in commercial banana plantations was enlightening. and learnings will be applied to my current PhD research on the biology of blood disease in Indonesia," Ms Ray said.

"My PhD research is part of a large program on emerging banana diseases funded by Horticulture Innovation Australia under the leadership of Professor André Drenth. Dr Lilia Costa Carvalhais, who is part of Prof Drenth's banana research team, led this part of the project investigating Moko in Costa Rica," Ms Ray said.

Jane Ray inspecting Earth University farm.

Internal fruit symptoms of blood disease of banana. © Andre Drenth

Costs associated with this activity were also funded by the National Plant Biosecurity Diagnostics Network grant for Moko Diagnostic Protocol Development, Horticulture Innovation Australia project BA 16005, and The University of Queensland.

"Because of this opportunity, I have gained unique practical experience and learned from an experienced team of plant pathologists about the management of this disease. I have been able to adopt and apply the learnings to my current ongoing research project on the biology of blood disease in Indonesia," said Ms Ray.

"This award has enabled an exchange of ideas and knowledge across vast geographic distances that will help to further the research into the control and management of the banana bacterial wilts, and it has allowed me to develop valuable networks for future projects."

This story was first published on the Crawford Fund website on 14 May 2020.

The world's favourite fruit needs a genetic boost

By Professor André Drenth

The world's most popular banana variety Cavendish is not the result of a breeding program but a banana variety found by a prehistoric farmer in a rainforest in Asia.

Ever since, Cavendish has been vegetatively propagated using small suckers sprouting from the base of the mother plant, and more recently, tissue culture processes to form the basis of our global banana export industry.

Over 40 per cent of bananas grown globally belong to this single variety.

Within Australia, over 95 per cent of the bananas grown in commercial plantations are of the Cavendish variety.

The majority of banana production is located in North Queensland, which produces more than 95 per cent of Australia's bananas with a gross value of production close to $600 million.

Although farmers select for shorter plants and better bunch characteristics, over time there has been no significant genetic gain in the global banana industry.

The cultivation of a single variety on a global scale has given rise to a very high level of genetic vulnerability.

The Cavendish variety is under threat from a range of fungal diseases, most notably Black Sigatoka and Fusarium Wilt Tropical Race 4 to which it has no resistance.

Black Sigatoka has spread widely. Almost one-third of the cost of growing Cavendish concerns the control of this disease using fungicides, which in some countries are applied each week.

Luckily, Australia is free from Black Sigatoka.

The other disease, Fusarium with TR4, is spreading across the world and is present in North Queensland where it is under active containment since it was first identified in 2015.

The most obvious solution to these problems is to breed bananas that are resistant to these diseases, but this is easier said than done.

The first problem is that the bananas we eat are sterile because they result from fruit formation without fertilisation.

Cavendish bananas are also triploid, and both male and female are sterile. In contrast, wild bananas are diploid, and produce lots of seed, making them unsuitable for consumption.

Native or wild bananas of different Musa species or subspecies occasionally fertilise each other. Then you end up with an infertile fruit lacking seed and they are the ones we can eat.

It's similar to how you produce a mule from a horse and a donkey, where the offspring is sterile.

The second problem is that not many fundamental genetic studies studies have been done on bananas, despite it being one of the top ten food crops in the world today.

In terms of other crop industries, bananas are still in the pre-domestication phase, and can be considered as an orphan crop suffering from a fertility crisis.

Very little basic research has been done on bananas, which was typical for crops grown by smallholders in the tropics.

We have not really domesticated bananas; we're still just using material from the wild. Although there is a lot of diversity within the Musa genus, very little as yet has found its way into the hands of the banana consumer.

Genetic improvement is needed to be able to effectively control plant diseases that threaten the cultivation of the Cavendish banana.

After a century of plant breeding, less than five per cent of the world's bananas actually come from a breeding program.

To investigate the reasons behind this situation and the challenges involved in developing new banana varieties – together with Professor Gert Kema from Wageningen University – I have edited a book on germplasm and genetic improvement of bananas, which was recently published by Burleigh-Dodds in the United Kingdom.

This volume is part of the three-part *Achieving Sustainable Cultivation of Bananas* series.

The first volume in the series, published in 2018, was on banana cultivation techniques. The second volume, published in 2020, deals with germplasm and genetic improvement. Volume three will cover diseases and pests of banana.

Volume two aims to cut across boundaries of botany, taxonomy, genetics, floral biology, molecular genetics, cytogenetics, genetic modification and plant breeding.

A lot of information is scattered among hundreds and hundreds of research papers, so what we try to do is what I call 'write what needs to be written'.

It's really about bringing all these diverse issues together and identifying key trends in a single easy-to-understand format.

The book contains information relevant for banana researchers, industry leaders and investors.

Macadamia innovation

Critically endangered macadamia species becomes a plant supermodel

One of the world's rarest tree species has been transformed into a sophisticated model that University of Queensland researchers say is the future of plant research.

"*Macadamia jansenii* is a critically endangered species of macadamia that was only described as a new species in 1991," said Robert Henry *(pictured)*, Professor of Innovation at QAAFI.

"It grows near Miriam Vale in Queensland and there are only around 100 known trees in existence."

However, with funding from Hort Innovation's Tree Genomics project, and UQ's Genome Innovation Hub, *Macadamia jansenii* has now become the world's most sophisticated plant research model.

Professor Henry said *Macadamia jansenii* was probably the best studied species on the planet in terms of its genetics.

"*Macadamia jansenii* has potentially become the model for assembling all future plant genomes," he said.

Professor Henry said the entire *jansenii* species grows in one small area.

"This means we have the potential to study the diversity of the whole species," he said.

"This is unusual, even for rare or endangered plants – it means we can get a lot of information about how rare plant species survive the impact of small population size and the associated genetic bottleneck."

Professor Henry said that particular characteristics of *Macadamia jansenii* made it useful for improving the technology and methodology for sequencing and assembling plant genomes.

"We investigated the different sequencing technologies, all the different software and algorithms that you can use in genomic sequencing, and then applied each of them to the same sample to find out what worked best," he said.

"It's a long, complex and very expensive process, so we wanted to use the latest technology to improve its efficiency."

The Genome Innovation Hub's Ms Valentine Murigneux analysed the genome sequence, and QAAFI researchers then assembled all 14 chromosomes for the species, in collaboration with laboratories in the United States. This work was published in *GigaScience*.

Professor Henry said the work is of great interest globally.

"High-quality genome sequences are proving much more useful than rough draft sequences, with less errors and better outcomes for plant breeding," he said.

Macadamia jansenii was first brought to the attention of Western plant scientists in 1983, by Ray Jansen, a canefarmer and skilled amateur botanist from South Kolan in Central Queensland.

Macadamia jansenii *nut set. Photo MCT.*

Ms Denise Bond, Executive Officer of the Macadamia Conservation Trust, said since 2018 about 60 new mature *Macadamia jansenii* trees have been located, although a quarter of these were destroyed in the bushfires of 2019.

"We very much welcome the genomic research on *Macadamia jansenii* as it will help prioritise future conservation efforts, although right now the most critical thing is to protect the remaining wild trees in their original habitat," Ms Bond said.

She said the remaining three macadamias species – *M. ternifolia, M. tetraphylla* and *M. integrifola* – were listed on the International Union for Conservation of Nature's Red List of Threatened Species in 2020.

"This is a wake-up call to Australia to take better care of our native macadamia species, she said.

Professor Henry said all four macadamia species – *tetraphylla, integrifolia, ternifolia* and *jansenii* – have now undergone the same analysis.

"It is fitting this work has been developed in Queensland using the Macadamia genus – one of Australia's few additions to the world's food crops," he said.

The macadamia genomic work forms part of a five-year project to develop detailed high-quality genome sequencing for five of Australia's key horticultural tree crops – avocado, macadamia, mango, citrus and almond – which account for 80 per cent of Australian horticulture tree crop value.

"The macadamia data we have generated has been fed through to a range of projects, including research on sustainably intensifying tree crop production and breeding for key commercial attributes in macadamia production," Professor Henry said.

This project is funded by Hort Innovation, the Department of Agriculture and Fisheries Queensland, and The University of Queensland.

Cracking a tough nut for macadamia growers

Macadamia researchers are breeding thinner shells for bigger kernels and tougher, pest-resistant husks.

Macadamia seedlings.

The University of Queensland's Professor Bruce Topp *(pictured)* said these combined attributes would boost Australia's $270 million industry, which earns $190 million in export income annually.

"Two-thirds of every harvested kilogram is in the weight of the macadamias' extremely tough shells. That's a lot of wasted productivity," Professor Topp said.

"The goal for many growers is to produce less shell and more kernel from each nut but with the shell still tough enough to resist pests."

Macadamias are native to south-east Queensland and northern New South Wales but are grown commercially in nations including Hawaii, South Africa and Brazil.

UQ, industry and the Queensland Government are jointly funding the QAAFI research.

"Tough outer husks help protect the nuts from pests, and thinner, inner shells produce larger nuts and profits," Professor Topp said.

"Thinner shells, however, improve access for the macadamia nut borer, a native pest that causes a lot of damage to young fruit.

"This requires more on-farm management, but biological control strategies are used widely and successfully.

"Growers introduce wasps to control borer moths, and owls to eat rats; rats and cockatoos quickly identify trees with thinner-shelled nuts."

Professor Topp leads the overarching $2.2 million, Horticulture Innovation Australia–funded National Macadamia Breeding and Evaluation Program.

"Building on decades of macadamia research, we are trialling sophisticated genomic technologies in the field, aiming to boost Australian macadamia growers' productivity and profitability," he said.

Hort Innovation's Dr Vino Rajandran said the global macadamia industry was currently using cultivars more than 60 years old and just a few generations from the wild.

"As a comparison, almonds have been cultivated for millennia," Dr Rajandran said.

"Compared with other horticultural tree crops, the macadamia does not currently yield its full potential and we'd like to change that.

"We are identifying molecular markers for key growth and production traits in diverse, wild macadamia samples.

"We hope this research will make Australian-bred macadamia cultivars the commercial, global varieties of choice."

Macadamias are Australia's second-biggest nut export, predicted to be worth $350 million by 2025.

Professor Topp said the program was also breeding for genetic resistance to 'husk spot', a fungal disease causing immature nut drop and cutting $10 million from industry profits a year.

It was also breeding smaller, warmer climate-adapted, high-yielding macadamia trees.

This research is funded by Hort Innovation using the Macadamia research and development levy, Australian Government contributions, with support from the Queensland Department of Agriculture and Fisheries and The University of Queensland.

NUTRITION AND FOOD SCIENCES

Innovation across the food supply chain

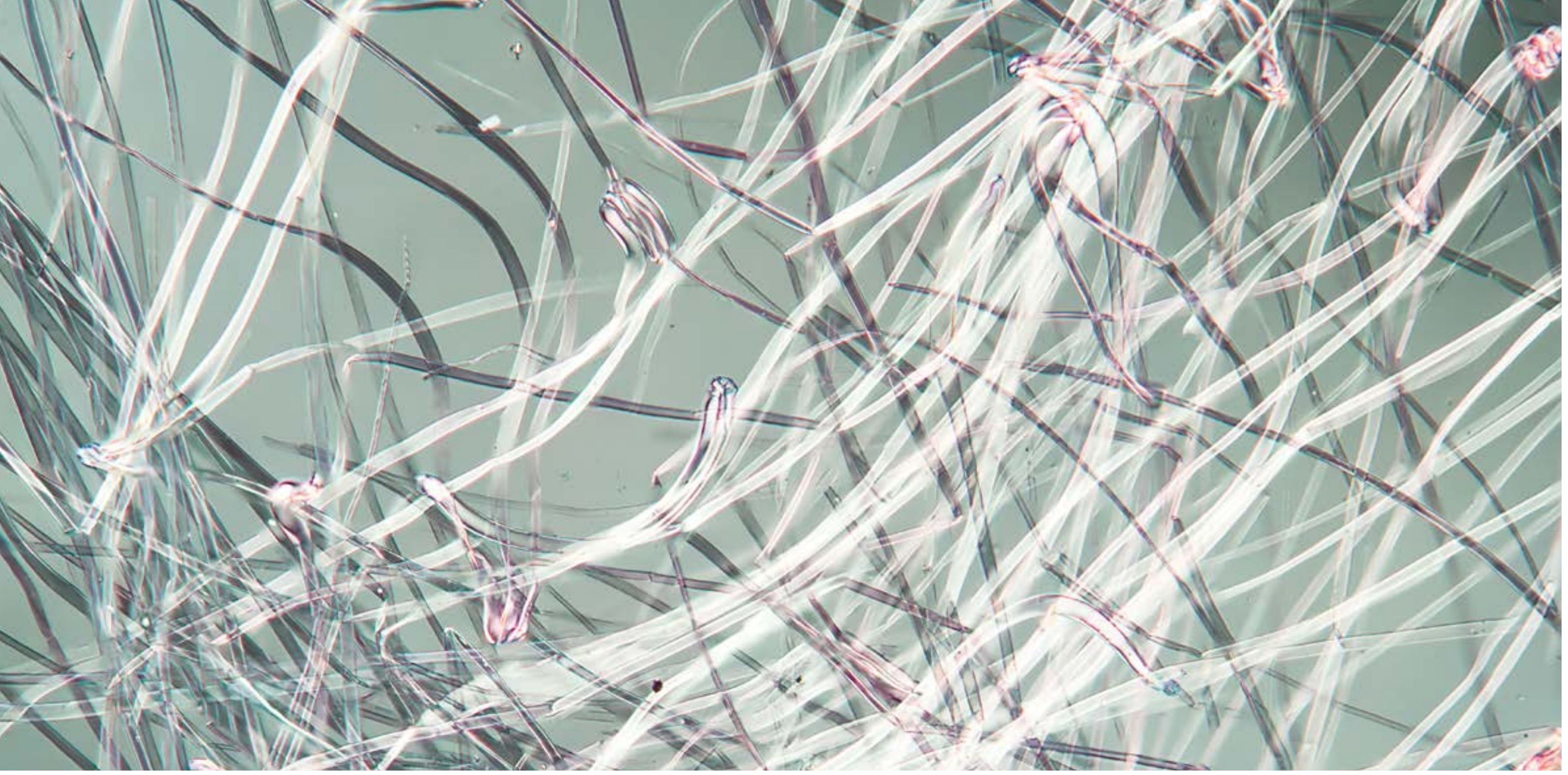
The Centre for Nutrition and Food Sciences supports enhanced health outcomes and economic benefits for Australia, by conducting integrated fundamental and applied research to improve the taste, quality, appearance, nutritional value and safety of food.

We aim to understand the fundamental characteristics of food that influence processing, food quality, consumer perception and nutritional value.

We support a 'fork to farm' consumer and nutritional focus to influence production choices across the agricultural industries.

Research themes:

- Smart selections
- Naturally nutritious
- Uniquely Australian



Secret of plant dietary fibre structure revealed

The secret of how fibre shapes the structure of plant cell walls has been revealed, with potentially wide-ranging applications, from nutrition and health to agriculture.

Researchers from The University of Queensland and KTH Royal Institute of Technology in Sweden have uncovered the mechanics of how plant cell walls balance the strength and rigidity provided by cellulose with its ability to stretch and compress.

UQ Director of the Centre for Nutrition and Food Sciences Professor Mike Gidley said the team identified that a family of cell wall polymers – hemicelluloses – played a critical role in balancing the need for rigidity with the flexibility to bend without breaking.

"This discovery is important for understanding dietary fibre properties in nutrition, but also for applications in medicine, agriculture and a range of other industries," Professor Gidley said.

"Plants don't have a skeleton, and their structures can range from soft, floppy grasses to the majestic architecture of a Eucalypt tree, with the key differences lying in their cell wall fibre structures."

The diversity of plant structures results from the three core building blocks of plant fibre – cellulose, hemicellulose and lignins – in the plant cell walls.

"Lignins provide the water-proofing in woody fibre, and cellulose is the rigid scaffolding material in almost all plant types, but the mechanical function of hemicellulose was something of a mystery," Professor Gidley said.

Professor Gidley and Dr Deirdre Mikkelsen, in collaboration with Dr Francisco Vilaplana at KTH's Wallenberg Wood Science Centre, experimented with two major components of hemicellulose – with dramatic effect.

"We tested the properties of cellulose when adding different proportions of the two components, and found that 'mannans' improved compression while 'xylans' drastically increased its stretchiness," Dr Mikkelsen said.

"We generated modified cellulose material in the laboratory that could be stretched to twice its resting length – the equivalent to watching a wet sheet of paper being stretched to double its length without tearing."

Professor Mike Gidley and Dr Deirdre Mikkelsen at The University of Queensland.

This research was published in *Nature Communications* on 17 September 2020. The team said its discovery had many applications, including in wound care and in the texture of plant foods.

"This information is also of interest for gut microbiome research in understanding more about how plant cells walls, or fibre, break down in the gut," Professor Gidley said.

"Complex plant fibre is already processed for low-value applications, but high-value materials are usually made from pure (bacterial) cellulose.

"Our work creates the basis for a new cellulose chemistry in which xylans and mannans are added to make composites with useful properties.

"This means new possibilities for developing better, environmentally sustainable plant-based materials, as well as selecting natural plant fibres with desirable properties in agriculture and food."

Waiter, there's a (black soldier) fly in my soup

It may seem a little hard to swallow but the larvae of a waste-eating fly could become a new alternative protein source for humans, according to a University of Queensland scientist.

Professor Louw Hoffman *(pictured)* said black soldier fly's larvae, which was already used for animal feed, was a high-quality protein.

"Just like meat, it contains all the nutrients humans need for health," Professor Hoffman said.

"The larvae is richer in zinc and iron than lean meat, and its calcium content is as high as that of milk."

"Their nutritional composition makes them an interesting contender as a meat alternative, and to date they have demonstrated their potential to partially replace meat in burger patties and Vienna sausages."

Professor Hoffman said the United Nation's Food and Agriculture Organization estimated that two billion people around the world already ate insects regularly as part of their diet.

"The biggest factor that prevents fly proteins being used in our food supply is Western consumers' acceptance of insects as food," he said.

"We will eat pea or oat milk, even lab-grown meats, but insects just aren't on Western menus."

Professor Hoffman has been studying the hurdles that need to be overcome before flies can directly enter the human food supply chain.

"There's a lot of research that's already been done on black soldier fly larvae as a feed for livestock, but we need to ensure we address safety issues before it can get legs as a human food," he said.

"This includes understanding the different nutritional profiles of the fly at key stages of its growth, and the best ways to process the fly to preserve its nutritional value.

"While the fly can clean up toxic waste, including heavy metals, it's also recommended that flies bred for human food be fed a clean source of organic waste."

In addition to its nutrition profile, Professor Hoffman said there were strong environmental reasons for humans to eat fly larvae.

It's estimated that less than half a hectare of black soldier fly larvae can produce more protein than cattle grazing on around 1200 hectares, or 52 hectares of soybeans.

"If you care about the environment, then you should consider and be willing to eat insect protein," he said.

Maggot patties and cooked maggots (below).

Barbecue dry aged wagyu porterhouse beef steak

Wagyu beef passes the taste test of science

A sensory scientist, a panel of professional taste testers, and an iconic beef brand are behind the world's first flavour wheel for Wagyu beef.

Developed by sensory and flavour expert Dr Heather Smyth from QAAFI at The University of Queensland (UQ), this innovative tool provides scientifically developed descriptors to articulate the specific sensory properties of different Wagyu cuts and marbling grades.

It was developed for the Australian Agricultural Company's (AACo) Westholme Wagyu brand, and paves the way for other premium Australian beef brands to stand out on menus around the world.

Flavour wheels are commonly used by the wine, seafood, coffee, beer and cocoa industries to describe flavour and sensory properties, but it's the first time this science has been applied to Wagyu beef. It's also thought to be a world first for any red meat.

It taps into how the 'terroir' – the unique environment of the vast, natural grasslands of Northern Australia where Westholme cattle are produced – and other factors, such as the animals' genetics, age, gender diet, handling and processing, imparts a unique flavour signature into Westholme beef.

Dr Smyth said the Westholme Wagyu flavour wheel springboards off the existing Meat Standards Australia (MSA) grading program to give this beef a point of difference to match its premium status.

"MSA provides a baseline quality measure for beef, but premium brands such as Westholme Wagyu are looking for points of distinction," she said.

"AACo wanted accurate and informative tools to describe the unique flavour and sensory properties of Westholme Wagyu, so we developed a language tool – a lexicon – that can be used for marketing and product education.

"AACo is leading the way with this science by taking a distinct approach to describing their product.

"The flavour wheel can be used by beef exporters and chefs to select Wagyu products based on the specific sensory experience they will provide consumers, including aroma, flavour, texture and after taste."

The flavour wheel is more than a marketing tool – it also demonstrates product credentials as a mark of integrity in the face of food fraud.

"Articulating the unique flavour and sensory attributes of Wagyu communicates inherent product qualities that cannot be easily imitated," Dr Smyth said.

This quality assurance can be used to reinforce the provenance of premium Wagyu beef.

Behind the flavour

AACo's CEO, Hugh Killen, said carefully developed nutritional strategies and high animal welfare are behind Westholme beef's unique flavour.

"Westholme's unique flavour profile is a combination of environment and genetics, which ultimately means no-one can replicate our flavour profile," Hugh said.

"Our cattle experience a quality of life that is inherent in the eating quality – the tenderness of the meat is a result of the respect and care with which the animal is raised.

"Westholme is AACo's premium brand for Wagyu beef and we know it tastes incredible but we were lacking the technical information, the science, to demonstrate to our customers why our brand is unique and how it tastes different.

"The objective of this project was to develop accurate and informative tools that detail the flavour and sensory properties of our Westholme Wagyu. The results have shown us that Westholme is distinctly different to other beef products.

"We want to be the first to show the value of our premium product at home and abroad – to clearly demonstrate the distinct flavours of home-grown, quality Australian beef and to have the lexicon to describe these differences.

"With the launch of the Westholme Flavour Wheel, we are now the only Wagyu brand in the world to have scientific support to reinforce our premium eating quality and talk to tasting notes specific to Westholme Wagyu. This also gives us the opportunity to continue to evolve, improve our product, and strive for excellence."

Development

Creating the wheel was the mouth-watering task of QAAFI's panel of sensory experts – a diverse group screened for their ability to detect subtleties in flavour and aroma, and trained to articulate these as 'product descriptors'.

During blind taste tests of beef from Westholme Wagyu and other premium brands, the panel identified almost 100 words to describe the samples based on:

Flavour: *e.g. sweet, savoury, salty*
Mouthfeel: *e.g. buttery, succulent, smooth*
Aftertaste: *e.g. lingering, clean, metallic*
Aroma: *e.g. honey, marrow and ashy*

Descriptors were developed for different cuts (tenderloin, striploin, and cube role) and for each marbling grade (4-5, 6-7, and 8-9+).

The sensory evaluation used a strict scientific method that relies on controlling the tasting environment, cooking and presentation.

A meat scientist oversaw the cooking process, to ensure each sample was grilled to medium with an internal temperature above 60°C.

The result is precise qualitative and quantitative sensory data that provides the technical backing, and provides consistent language to demonstrate the unique taste of different Wagyu products.

So how did Westholme stack up?

"I would describe the flavour of Westholme Wagyu as intensely caramelised and roasted, a tender juiciness, buttery and dissolving sweetness in-mouth that lingers," Dr Smyth said.

Dr Heather Smyth in the sensory test kitchen (above) and sharing a Wagyu steak meal (below).

"Some cuts are more delicate, with complex notes such as game meat, white pepper notes, fresh bread crust, and hints of brassica."

Future applications of this research include extending the flavour wheel to different cooking methods that can influence taste, as well as to beef from other breeds.

The technical descriptors could be used by food judging panels, and set an industry standard for products.

Dr Smyth envisages this flavour science could even spearhead geographical indicators such as 'western Queensland Wagyu' as a clear mark of provenance and quality comparable to Coffin Bay oysters or King Island cheese.

"This research lifts Australian beef to a new standard, to lead the world as producers of distinctive, quality food."

This research was funded by the Australian Agriculture Company, with support from The University of Queensland and Queensland Department of Agriculture and Fisheries.

Digital signature technology authenticates food

Efforts to ensure that consumers are actually getting what they pay for have taken another step forward with advances in food forensics verifying that techniques already used in agriculture can also identify food fraud in fisheries.

QAAFI's research in the field of food provenance and traceability is crucial to protecting premium markets.

As part of this work Associate Professor Daniel Cozzolino *(pictured)* from the Centre for Nutrition and Food Sciences is focusing on chemometric and spectroscopic techniques to create and verify "digital signatures" of food.

In a recent international research collaboration with Dr Aoife Power, from the CREST Technology Gateway of Technological University Dublin, Dr Cozzolino was able to identify adulterated crabmeat.

In one instance, batches of Atlantic blue (*Callinectes sapidus*) crabmeat had been "padded" with cheaper blue swimmer (*Portunus armatus*) flesh. In another, batches of crab meat were found to be padded with imitation crab, known as surimi or seafood extender.

Reading digital signatures

Dr Cozzolino applies spectroscopy to his samples, using electromagnetic waves to determine its composition. He uses chemometric techniques, applying algorithms to analyse and process the spectrographic data. The combination of the two fields of research results in a digital signature, or fingerprint, of food.

Dr Cozzolino says a key step in the process is developing the specifications for a particular food product – establishing the baseline fingerprint or signature. This can then be used to either verify a product, or detect food fraud, an issue particularly relevant to fish and seafood, which are considered the commodity most susceptible to mislabelling globally.

However, applications of the technology are much broader, and can be applied from point of origin through to processing final purchase, allowing closer monitoring of the whole value supply chain.

Dr Cozzolino and Dr Aoife also identify spectroscopy at work aboard a commercial freezer trawler in their research that was published by *Applied Sciences* in June 2020. Spectrographic scanners were able to differentiate between frozen and thawed prawns, and identify differences in salt content, pH and cooking periods.

The new scanning technology provides almost instant results, and can in some cases be done remotely, with drones or sensors. The scans are non-invasive and environmentally friendly, unlike traditional methods of analysing food and seafood, which generally involve the destruction of the sample being tested, and which are also slower to produce results.

At present a handheld infra-red scanner costs about US$25,000, but Dr Cozzolino says new models were coming to the market priced as low as US$5,000.

The food journey

But establishing the digital signature of a product remains the critical first step. At QAAFI, the scanning technology is also being used to identify and verify the provenance of wine, honey, and even the native Kakadu plum.

For the Kakadu plum project, researchers were able to pinpoint whether a particular fruit had grown in a coastal area or inland region. "Just based on the spectra and doing some big data machine learning, we were able to identify the origin of a particular fruit," Dr Cozzolino says.

Dr Cozzolino says bio-spectroscopy can be used to analyse single grains of barley to determine the ratio of lipids, esters, proteins and carbohydrates. Farmers can then focus on growing the varieties of barley best suited for a specific market, such as beer production.

The technology can also be used to record the journey of produce from the farm to the table.

Dr Cozzolino says the technology appeals to farmers, who can use it to improve the quality of their produce and guarantee provenance. Processors can use it for quality assurance purposes, and regulators can use it to ensure food safety.

Some agricultural equipment manufacturers already sell harvesting machines equipped with spectroscopy scanners to monitor the composition and quality of what's being harvested, and New Zealand-based dairy company Fonterra uses spectroscopy in its processing plants to monitor the quality of raw milk.

Food forensics

"Food forensics is becoming very important in the areas of food provenance, fraud and authentication," he says. "Now we know that the spectra can contain a digital signature of a food, and if we do anything to that food, if we change anything for that particular food, either by heating it or not heating it, changing the storage conditions or adding something else, then that digital signature is going to change."

Dr Heather Smyth, a senior research fellow at QAAFI, says Dr Cozzolino's work in spectroscopy is a powerful tool in the field of food provenance.

Just like wine, many foods have flavour nuances that relate to the region in which they're grown, says Dr Smyth, who specialises in flavour chemistry and sensory evaluation.

"In Australia, provenance is huge. Our producers have quality premium products. Our food is more expensive to produce, and we produce it sustainably and ethically and to high-quality standards. As a result, the food tastes better."

"Those who produce these products want to protect them, and people all over the world, of course, want to copy them," she says. The copies, of course, don't taste as good as the original, and the fakes end up damaging the brand of the producers who have invested heavily in good production processes and the provenance of their product.

"That's the power of this technology; it provides that authentication, that guarantee that the product is authentic, whether it's barramundi that's been farmed at Humpty Doo or a Coonawarra shiraz," Dr Smyth says.

Orange capsicums on the menu for long-term eye health

First carrots and now capsicum have been identified as good for your eyes – and it is the nutrient linked to the orange colour that counts. Researchers in the Naturally Nutritious research program have identified a rich source of zeaxanthin in orange capsicums.

Just as carrots were found to promote night vision through a nutrient called beta-carotene, now another orange vegetable has been found to be pivotal for eye health.

Research by Associate Professor Tim O'Hare *(pictured)* has identified orange capsicums as the richest source of the orange pigment zeaxanthin, which is vital for central vision.

He is now helping to address the lack of zeaxanthin in our diets through research funded by Hort Innovation, as part of the Naturally Nutritious research program that seeks to increase the level of nutrients in fruit, vegetables and nuts.

Nutrition you can see

"I'm particularly interested in products that can be visually identified by consumers as containing vital nutrients," Dr O'Hare said.

"A number of nutrients we are interested in for human health are actually pigmented. In most cases, it's the zeaxanthin itself that gives orange capsicums their vivid orange colour."

Another example of this is the purple pigment anthocyanin, found in purple sweetcorn.

"With these nutrients, what you see is what you get – the more intensely coloured the product, the more nutrient they contain," Dr O'Hare said.

When it comes to orange zeaxanthin and health, Dr O'Hare said the compound accumulates in our macula, at the back of our eyes. It protects against blue light, which is particularly damaging because it can oxidise our photoreceptors, leading to macular degeneration.

As such, zeaxanthin deficiency leaves eyes susceptible to age-related macular degeneration, which in Australia affects one in seven people over 50 years of age, and one in three over 80.

Too much blue light can damage the light receptors (called cones) in the retina that are responsible for high-resolution central vision and colour perception.

The more zeaxanthin in your macula, the more blue light is naturally screened from hitting the back of the eye.

Dr O'Hare stressed food is essential to achieve this protection: "Our bodies can't make zeaxanthin, which means we rely exclusively on dietary sources or on artificial supplements," he said.

High zeaxanthin

A comparative analysis of different fruit and vegetables identified orange capsicums as by far the richest source of zeaxanthin.

One capsicum (typically 450 grams) was found to contain zeaxanthin levels equivalent to 30 supplement tablets, with two milligrams of zeaxanthin the daily recommended dose.

"Each zeaxanthin tablet is roughly equivalent to 10 grams of orange capsicum flesh – that's how rich the capsicums are in this pigment," Dr O'Hare said.

"The trouble at the moment is that orange capsicums are not always available in shops, something we are looking to overcome."

In contrast, the 'traffic light' capsicums – coloured red, yellow and green – contain no zeaxanthin.

The analysis also compared zeaxanthin levels among the different orange capsicum varieties that are available in Australia.

A total of eight orange varieties of capsicum were analysed, with seven all proving to be rich sources of zeaxanthin. The eighth, however, owes its orange colouring to a mix of red and yellow pigment. "Mix these two colours together and you get a dark orange fruit, but sadly no zeaxanthin," Dr O'Hare said.

Breeding program

At QAAFI, PhD candidate Rimjhim Agarwal is working to better understand how orange capsicums accumulate zeaxanthin, with the goal of producing genetic tools to help select and breed for higher zeaxanthin production.

Ultimately, the goal of the research is to make it agronomically viable and profitable for growers to produce more orange capsicums, and to alert consumers to their special health benefit of preserving eyesight – thereby creating demand.

The trick is to coordinate the increase in demand with supply, which includes ensuring that there are no constraints on Australian farms to growing orange capsicums.

Dr O'Hare has a tip for consumers who already include zeaxanthin-producing capsicums in their diets: "Zeaxanthin is fat-soluble, so it's best served with a helping of olive oil or salad dressing to aid absorption," he said.

"Raw works well, although cooking the capsicum can also help by breaking down the cell walls to better release the zeaxanthin. But don't overcook them, as overcooking will cause some of the zeaxanthin to break down."

While zeaxanthin does occur in other vegetables, the levels tend to be quite low.

However, Dr O'Hare is exploring ways to increase zeaxanthin production in other vegetables, and he has produced orange-coloured corn that contains 10 times more zeaxanthin than its yellow counterpart.

Even so, it cannot rival the levels found in orange capsicums.

As capsicum and chilli belong to the same species, Dr O'Hare is also exploring opportunities to cross the ability to make and accumulate zeaxanthin into chillies.

For those who like it hot, one high-zeaxanthin chilli a day could be enough to help stave off macular degeneration.

This project is funded by Hort Innovation, The University of Queensland and the Department of Agriculture and Fisheries, Queensland.

Indigenous Australian wattleseed was used to make these gut-healthy bread rolls. Photo: QAAFI.

Exploring the cultural heritage and nutrition of wattle seeds

Ms Sera Jacob's research involves studying the uniqueness of some specific indigenous Australian wattle seed varieties and developing nutrient–dense products using the wattle seeds.

Wattle seeds are a nutrient powerhouse full of iron, fibre, and protein, and offer an exciting and unique potential as a major food ingredient in conventional food options.

Ms Sera Jacob *(pictured)* is looking at different varieties harvested around Alice Springs along with different processing methods. Her aim is to discover information that may help improve the way our bodies absorb nutrients from these seeds.

Ms Jacob's work also focuses on Indigenous engagement and ethically understanding the traditional knowledge connected to wattle seeds.

This project is funded under the ARC Training Centre for Uniquely Australian Food and supported by Karen Sheldon Catering. Her advisors are Professor Mike Gidley, Associate Professor Heather Smyth, Dr Bernadine Flanagan, and Dr Barbara Williams.

Native seeds, particularly wattle seeds, will be explored in terms of bioavailability of dietary fibre, starch and phytonutrients in partnership with Karen Sheldon Catering.

The project will involve exploring different cultivars of wattle seeds for nutritional properties in gut models to identify product-specific market opportunities.

Wattle seeds (*Acacia sp.*) have historically been an integral part of the Australian Aboriginal diet.

Full of protein, useful dietary fibre, iron and zinc, the seeds from specific varieties hold a lot of significance both nutritionally and spiritually in their lives.

"As both a scientist and someone who holds my tradition and culture close to my heart, I was thrilled at the opportunity to interact with communities and learn the traditions of their food," Ms Jacob said.

Ms Jacob assisted with the Future Stars Training Program, a monthly training program organised by Saltbush Enterprises of Karen Sheldon Group (KSG).

The training program is an Indigenous pre-employment program aimed at empowering local Aboriginal jobseekers by training them with life skills and improving their employability as a significant contribution towards closing the gap on Indigenous economic disadvantage.

"Sarah Hickey, partner, and Business Development Manager at KSC and Director of Saltbush Enterprises was a delight to meet," Ms Jacob said.

"Her energy is truly infectious."

Treats are made using different varieties of roasted wattle seeds.

"Over the span of two weeks, I also had the privilege to spend time daily with Rayleen Brown, owner of Kungkas Can Cook, trainer for the Future Stars Program with KSG, and a widely renowned advocate for Indigenous cultural protection and empowerment," Ms Jacob said.

"I even assisted her as she undertook yet another one of her amazing masterclasses on the culinary wonders of the desert, beautifully set up on the Larapinta Trail."

Pectin, another reason to love mangoes

The dietary fibre pectin found in fruit and vegetables plays a crucial role in digesting fats and improving gut and heart health.

Mangoes, apples and citrus fruit are all good sources of the dietary fibre pectin, and new research reveals how it helps to regulate cholesterol levels.

The findings come from Dr Nima Gunness *(pictured)* at QAAFI, a research institute at The University of Queensland.

Her work involves translating food, nutritional science and health science into effective information that can reliably promote wellbeing.

"Identifying the role of dietary fibre is the focus of my most recent research," Dr Gunness said.

Dietary fibres are composed of soluble and insoluble fibres, which are located in the cell walls of plants and are not digested by the human body.

"Typically, the insoluble fibres are viewed as a way to maintain bowel regularity and provide bulk to diets without associated calories," Dr Gunness said.

Some soluble fibres, such as pectin, ferment in the lower gut of the human body.

They are known to have beneficial effects on fat metabolism and improve cardiovascular health, such as blood levels of cholesterol and triglycerides – although how they do this was a mystery for a long time.

Now, Dr Gunness has discovered a link between soluble fibre and fat metabolism through previously unsuspected impacts on bile acid metabolism.

The good bile

Soluble fibre in the form of pectin (sourced from fruits and vegetables) promotes the production of 'therapeutic' bile acids.

This subtype of bile acids helps maintain a healthy digestive tract and cholesterol balance. This subsequently protects the cardiovascular system.

The soluble fibre also reduces levels of 'toxic' bile acids known to promote diseases, including colorectal cancer.

The therapeutic form of bile acid is called ursodeoxycholic acid (UDCA), while the toxic form is called lithocholic acid (LCA).

"The link between dietary fibre, the digestion of fats, and bile acid chemistry is an emerging area of importance when it comes to food choices," Dr Gunness says.

"I think people will soon be hearing a lot more about 'therapeutic bile acids' and the importance of dietary fibre in producing them."

QAAFI's Centre for Nutrition and Food Sciences uses advanced research methods to probe the rich and deeply interconnected complexity between food, healthy physiology, and metabolism.

Her research examined a class of soluble fibre called pectin.

Unlike the beta-glucans that are found in, for example, grains such as oats and barley, pectin is sourced from fruits and vegetables.

Identifying health benefits

Dr Gunness's study into the physiological effects of pectin involved a trial with pigs because of their physiological similarity to humans.

The analysis included impacts on the digestive tract and on the level of markers for cardiovascular health in plasma.

> *"New research uncovers a link between soluble fibre and fat metabolism, through previously unsuspected impacts on bile acids.*

The pigs were fed three contrasting diets: a standard 'control' diet; one containing unprocessed pectin sourced from mango pulp; and one containing extracted pectin.

The pigs were gradually introduced to their diets before the 28-day feeding experiment began.

Comparing the impacts of the three diets at the end of four weeks, the study confirmed that pectin reduces cholesterol levels in plasma. Levels fell 18 per cent in animals fed the extracted pectin diet, and 10 per cent for unprocessed pectin diet.

Both pectin diets also increased levels of therapeutic bile acids and markers of gut health, implying the enhancement of good gut microbiota.

Dr Gunness said the study also shed light on the mechanisms mediating these important effects.

She said bile acids enter the small intestine to assist the digestion of fats.

The primary bile acids are formed in the liver from cholesterol, and stored in the gall bladder before they are excreted into the duodenum (first part of the small intestine) when food is released from the stomach.

"The primary bile acids released by the gall bladder undergo a series of chemical transformations as they travel through the digestive tract," Dr Gunness said.

"These chemical transformations can result in both healthy and toxic forms of bile acid, depending on the state of the digestive tract, particularly the gut microbiota."

"What we saw is that pectin exerts beneficial effects by priming the digestive system towards transforming bile acids into forms that benefit gut and cardiovascular health.

"The key health benefits of pectin can be obtained with both fruit pulp and extracted pectin," Dr Gunness said.

"That creates an opportunity to consume more fruits and vegetables, and to beneficially supplement diets with extracted pectin – although the extracted pectin should have particular characteristics," she said.

"The extraction processes involved are critical for health benefits, which means that not all supplements will give the same benefits."

The study was funded by the Australian Research Council (ARC) and undertaken in collaboration with the University of Adelaide and the University of Melbourne via the ARC Centre of Excellence in Plant Cell Walls.

Supporting information

Employees and students of the Queensland Alliance for Agriculture and Food Innovation in 2020.

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QAAFI Honorary and Adjunct Appointments

QAAFI Affiliates

QAAFI Operational Staff

QAAFI Technical Staff

QAAFI Research Higher Degree Students

Publications

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Dr Geoffry Fordyce	Senior Research Fellow
Dr Mehrnush Forutan	Postdoctoral Research Fellow
Dr Natasha Hungerford	Research Fellow
Dr Peter James	Senior Research Fellow
Dr Jun Liu	Research Fellow
Professor Timothy Mahony	Professorial Research Fellow
Dr Mona Moradi Vajargah	Postdoctoral Research Fellow
Dr Loan Nguyen	Research Fellow
Dr Lida Omaleki	Research Officer
Dr Luis Prada e Silva	Senior Research Fellow
Dr Raza Ali	Research Officer
Dr Elizabeth Ross	Research Fellow
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Professor Alan Tilbrook	Professorial Research Fellow
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Dr Kai Voss-Fels	Senior Research Fellow

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Professor Frederik Botha	Honorary Professor
Dr Yashvir Chauhan	Honorary Associate Professor
Dr Marisa Collins	Honorary Senior Fellow
Professor Appolinaire Djikeng	Honorary Professor
Dr Sandra Dunckel	Honorary Fellow
Dr Glen Fox	Honorary Senior Lecturer
Professor Elliot Gilbert	Honorary Professor
Dr Yingbin He	Honorary Senior Fellow
Professor Mario Herrero	Honorary Professor
Dr Arief Indrasumunar	Honorary Fellow
Professor Wayne Jorgensen	Honorary Professor
Professor Kemal Kazan	Honorary Professor
Associate Professor Athol Klieve	Honorary Associate Professor
Associate Professor Slade Lee	Honorary Associate Professor
Professor Qiaoquan Liu	Honorary Professor
Associate Professor Michael Mackay	Honorary Associate Professor
Associate Professor Sudheesh Manalil Velayudhan	Honorary Associate Professor
Associate Professor Stuart McLennan	Honorary Associate Professor
Dr Jessica Morgan	Honorary Fellow
Dr Miranda Mortlock	Honorary Senior Fellow
Dr Simone Osborne	Honorary Senior Fellow
Dr Vishal Ratanpaul	Honorary Fellow
Dr Hannah Robinson	Honorary Fellow
Dr Manuel Rodriguez Valle	Honorary Professor
Professor Maurizio Rossetto	Honorary Professor
Professor Michael Rychlik	Honorary Professor
Professor Roger Shivas	Honorary Professor
Professor Blake Simmons	Honorary Professor
Assoc. Prof. Dharini Sivakumaran	Honorary Associate Professor
Dr Francisco Vilaplana	Honorary Fellow
Dr Stephen Were	Honorary Senior Research Fellow
Professor Rod Wing	Honorary Professor
Professor Colin Wrigley	Honorary Professor
Dr Wai Yong	Honorary Fellow

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Associate Professor Graham Bonnett	Adjunct Professor
Dr Bruce D'Arcy	Adjunct Senior Fellow
Dr John Dixon	Adjunct Professor
Dr Rosalind Gilbert	Adjunct Fellow
Dr Lisa-Maree Gulino	Adjunct Fellow
Emeritus Professor Wayne Hall	Adjunct Professor
Associate Professor Mark Hickman	Adjunct Associate Professor
Associate Professor David Innes	Adjunct Associate Professor
Associate Professor Robert Karfs	Adjunct Associate Professor
Dr Brian Keating	Adjunct Professor
Associate Professor Zivile Luksiene	Adjunct Associate Professor
Associate Professor William Macleod	Adjunct Associate Professor
Professor Lynne McIntyre	Adjunct Professor
Associate Professor Sarah Meibusch	Adjunct Associate Professor
Dr Ram Mereddy	Adjunct Associate Professor
Dr Diane Ouwerkerk	Adjunct Fellow
Adjunct Professor Gregory Platz	Adjunct Professor
Dr Richard Silcock	Adjunct Senior Fellow
Associate Professor Youhong Song	Adjunct Associate Professor
Dr Michael Sweedman	Adjunct Fellow
Dr Leena Tripathi	Adjunct Professor
Lynne Turner	Adjunct Professor
Associate Professor Lizzie Webb	Adjunct Associate Professor
Associate Professor Neil White	Adjunct Associate Professor
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Professor Wayne Bryden	Affiliate Professor
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Liz Eden	Administration Officer/Marketing
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Tyne Hamilton	Marketing and Communications Officer
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Cassie Martinez	Administrative Officer
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Joseph Murdoch	Community and Industry Engagement Officer
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David Rodgers	Senior IT Support Officer
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Angie Strelow	Project Manager, Hy-Gain Project
Bronwyn Venus	Research Partnerships Manager
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Fiona Zhao	Grant Administration Officer

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Wen Yee	Research Assistant

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Dagong Zhang	Senior Research Assistant

QAAFI Higher Degree by Research Candidates

Centre for Animal Science

Name	Program	Supervisor	Project Title
Stephen Baldwin	MPhil	Prof Timothy Mahony	The development of novel approaches for the detection of the pathogens associated with Bovine Respiratory Disease
Sadia Chowdhury	PhD	Prof Mary Fletcher	Authentication of uniquely Australian food products with claimed health benefits
James Copley	PhD	Prof Ben Hayes	Improving fertility in northern beef cattle with genomic selection
Andrew Ferguson	PhD	Prof Timothy Mahony	Immunological difference in Bovine Respiratory Disease susceptibility
Russell Gordon	PhD	Prof Mary Fletcher	Mitigating the effects of the plant toxin Simplexin on Australian livestock
Muhammad Kamran	PhD	Dr Peter James	Variation amongst cattle in susceptibility to the effects of ticks and biting flies and the determination of phenotypic and immunological markers for resistance
Thomas Karbanowicz	PhD	Prof Ala Tabor	The development and application of novel and innovative approaches to identify potential vaccine antigens in economically significant ticks
Ai Hwee Kho	PhD	Dr Peter James	Detecting Haemonchus contortus infection in sheep using infrared spectroscopy
Harrison Lamb	PhD	Dr Elizabeth Ross	Crush side genotype to accelerate genetic gain in livestock
Zhi Hung Loh	PhD	Prof Mary Fletcher	Mitigating the effects of the toxin simplexin in Pimelea poisoning of cattle by developing a microbial probiotic
Mukund Madhav	PhD	Dr Peter James	Transinfection of buffalo flies with Wolbachia and characterisation of biological effects
Emily Mantilla Valdivieso	PhD	Prof Ala Tabor	Cattle tick and buffalo fly host biomarkers for resistance
Muhammad Naseem	PhD	Dr Peter James	Pathogenesis of buffalo fly lesions and factors determining variation in susceptibility amongst cattle
Chian Teng Ong	PhD	Prof Ala Tabor	Pathogenomics of infectious causes of bovine infertility in northern Australia
Xiaochen Sun	PhD	Dr Conny Turni	Studies on Glaesserella australis
Katelyn Tomas	PhD	Prof Ala Tabor	Early life stress and subsequent stress resilience and emotionality in pigs
Christie Warburton	PhD	Prof Ben Hayes	Genomics approaches to improve productivity in cattle
Tristan Wimpenny	PhD	Prof Timothy Mahony	Identification of the role of microRNAs in Bovine Herpesvirus 1 replication and virulence.
Melissa Wooderson	PhD	Prof Alan Tilbrook	Analgesia and Haemostasis to achieve high standards of beef calf welfare in northern Australia
Seema Yadav	PhD	Prof Ben Hayes	Optimising genomic selection in sugarcane

Centre for Crop Science

Name	Program	Supervisor	Project Title
Oluwaseun Akinlade	PhD	AsPr Lee Hickey	Understanding the genetics of crop root architecture
Othman Aldossary	PhD	Prof Robert Henry	Jojoba genomics for stress tolerance
Bader Alsubaie	PhD	Prof Robert Henry	Jojoba genomics for sex determination
Asad Amin	PhD	AsPr Lee Hickey	Integrating crop modelling and genomics to improve plant breeding
Galaihalage Ananda	PhD	Prof Robert Henry	Sorghum Genomics: Diversity and evolution of the Sorghum genus and the role of cyanogenesis
Jed Calvert	PhD	Dr Roger Shivas	Fungal Endophytes in the Iron Range
Vallari Chourasia	PhD	Prof Robert Henry	Catalytic conversion of Sugarcane Bagasse into aromatics and high-value platform chemicals
Andrew Fletcher	PhD	Dr Karine Chenu	Understanding the genetic and physiological basis of transpiration efficiency in Australian wheat
Tolera Fufa	PhD	Prof Ian Godwin	Identification of heterotic pools in maize germplasm adapted to mid altitude sub humid agro-ecology of Ethiopia
Geetika	PhD	AsPr RCN (Nageswararao) Rachaputi	Physiological constraints to yield of mungbean in dryland and irrigated conditions
Uwe Grewer	PhD	Prof Daniel Rodriguez	Bio economic modelling of farming systems under climate change for ex ante assessments of agricultural development policies
Sharmin Hasan	PhD	Prof Robert Henry	Diversity of domestication loci in wild rice populations
Katrina Hodgson-Kratky	PhD	Prof Robert Henry	Analysis of biomass traits in sugarcane (Saccharum spp. hybrids)
Colleen Hunt	PhD	Prof David Jordan	Improved methods of predicting genetic merit in plant breeding programs using linear mixed models
Dilani Jambuthenne Gamaralalage	PhD	AsPr Lee Hickey	Mining the Vavilov wheat diversity panel for new sources of adult plant resistance to stripe rust
Yichen Kang	PhD	AsPr Lee Hickey	Improving root system architecture of future crops
Sana Ullah Khan	PhD	AsPr Lee Hickey	Accelerated genome editing to speed up genetic gain in crops
Asad Khan	PhD	AsPr Bhagirath Chauhan	Biology of Amaranthus retroflexus and Amaranthus viridis
Tom Kukhang	PhD	Prof Robert Henry	Genetic analyses of an 8 x 8 set of full diallele crosses and mass propoagation via somatic embryogenesis of elite (Coffea Arabica L.) hybrids from the CIC Coffee Breeding Program
Yasmine Lam	PhD	Prof Ian Godwin	Analysis of PIN and VRN families in cereals to manipulate plant architecture
Mengwei Li	MPhil	Dr Joe Eyre	Sorghum and maize establishment in cold and drying soils
Amy Mackenzie	PhD	Dr Sam Periyannan	Protecting wheat from stripe rust disease through rapid transfer of resistance from landraces
Patrick Mason	PhD	Prof Robert Henry	Investigating the transcriptional control of UDP-Glucose metabolism in Sugarcane
James McLean	MPhil	Prof Daniel Rodriguez	Proximal sensing as a tool to assist data collection in extensive maize and sorghum agronomic trials
Donald McMurrich	MPhil	Prof Ian Godwin	Canopy Manipulation of Sorghum to create a more efficient, stress tolerant plant with increased yield
Angela O'Keeffe	PhD	Prof Robert Henry	Genetic solutions for determining fibre quality traits in sugarcane
Adhini Pazhany	PhD	Prof Robert Henry	Expression genomics to widen the gene pool of sugarcane for improved biomass partitioning
Virginie Perlo	PhD	Prof Robert Henry	Metabolic and transcriptomic changes in the developing sugarcane culm associated with high yield and early-season high sugar content
Charlotte Rambla	PhD	AsPr Lee Hickey	Optimising root systems in wheat
Dipika Roy	PhD	AsPr Lee Hickey	Understanding the genetics of spot blotch resistance in barley
Mahendraraj Sabampillai	PhD	AsPr RCN (Nageswararao) Rachaputi	Genotypic variation for effect of heat stress during reproductive phase in pigeonpea.
Loretta Serafin	PhD	Prof Daniel Rodriguez	Improving the reliability and profitability of sorghum in north west NSW
Raghvendra Sharma	PhD	Dr Sam Periyannan	Molecular genetic characterisation of stripe rust resistance genes from Vavilov's wheat collection
Priyanka Sharma	PhD	Prof Robert Henry	Macadamia genomics
Kanwal Shazadi	PhD	Dr Karine Chenu	Can genetic variations in root architectural development during the crop cycle affect wheat productivity in water-limited environments?
John Smith	PhD	Prof Michael Bell	The impact of irrigation methods and management strategies on nitrogen fertiliser recovery in cotton in southern QLD
Basam Tabet	PhD	Prof Ian Godwin	Manipulating sorghum grain size and plant architecture
Zerihun Tadesse Tarekegn	PhD	AsPr Lee Hickey	Integrating speed breeding and association mapping strategies to identify and introgress genes for key pathology and agronomic traits in bread wheat in Ethiopia
Fatemeh Vafadarshamasbi	PhD	Prof Graeme Hammer	Beat the heat: Improving sorghum productivity under a changing climate
Prameela Vanambathina	PhD	AsPr RCN (Nageswararao) Rachaputi	Assessment and identification of molecular markers underpinning for H. armigera Hubner resistance in Australian wild Cajanus species
Xuemin Wang	PhD	Prof David Jordan	Impact of variable water limited environments on grain sorghum yield and lodging in Australia
Albert Wong	PhD	Prof Andrew Borrell	Manipulation of genes to manage drought resistance in field crops
Muhammad Yahya	PhD	Dr Karine Chenu	Mechanisms to improve grain yield and grain quality under heat in wheat
Mengge Zhang	MPhil	AsPr Lee Hickey	A tool box for developing wheat cultivars with improved root systems
Xiaoyu Zhi	PhD	Dr Barbara George-Jaeggli	Predicting photosynthetic capacity from hyperspectral data in sorghum

Centre for Horticultural Science

Name	Program	Supervisor	Project Title
Michael Bird	PhD	AsPr Craig Hardner	Maximizing gains from selection in Eucalyptus
Fernanda Borges Naito	PhD	AsPr Ralf Dietzgen	Differential plant gene expression in response to tospovirus and rhabdovirus infection and viral counter-defense
Mohamed Zakeel Cassim	PhD	AsPr Olufemi Akinsanmi	Unravelling the biotic cause and interaction of abnormal vertical growth in macadamia
Grant Chambers	MPhil	AsPr Andrew Geering	Study of viroids in Australian citriculture
Hsu-Yao Chao	PhD	AsPr Andrew Geering	Improving surveillance strategies for tospoviruses and thrips to enhance the biosecurity of the nursery industry

Daniel Edge-Garza	PhD	Dr Craig Hardner	Global prediction for genetic improvement of apple
Bao Tram Hoang	PhD	Prof Neena Mitter	Investigating the Fate of Topically Applied dsRNA in the Environment
Ritesh Jain	PhD	Prof Neena Mitter	Topical application of RNA interfrence to manage insect pests of horticultural crops
Olumide Jeff-Ego	PhD	AsPr Olufemi Akinsanmi	Occurence and pathogenicity of Phytophthora in macadamia in Australia
Emily Lancaster	PhD	Prof Andre Drenth	Epidemiology, impact and management of myrtle rust in lemon myrtle plantations
Zhi Xian Lim	PhD	Prof Neena Mitter	RNAi-based management of Helicoverpa armigera
Thi Phuong Thuy Mai	PhD	Prof Bruce Topp	Genomic-assisted exploitation of wild germplasm for improvement of macadamia
Vheena Mohankumar	PhD	AsPr Olufemi Akinsanmi	Biology and epidemiology of Botryosphaeria associated with branch dieback and tree death in macadamia
William Nakford	PhD	Prof Neena Mitter	Topical application of biomolecules to manipulate the adventitious rooting pathway
Onkar Nath	PhD	Prof Neena Mitter	Improving avocado through genomic analysis
Thu Ha Ngo	PhD	AsPr Andrew Geering	Post-translational processing of the caulimovirid capsid protein and utilisation of antipeptide antibodies for diagnosis
Alexander Nilon	PhD	Prof Neena Mitter	BioClay for control of Tomato Spotted Wilt Virus
Jasmine Nunn	PhD	Prof Bruce Topp	Genetic variation in Macadamia for resistance to Husk Spot, Pseudocercospora macadamiae
Sari Nurulita	PhD	AsPr John Thomas	Virus-infected garlic in Australia and Indonesia, and factors affecting disease epidemiology
Christopher O'Brien	PhD	Prof Neena Mitter	Cryopreservation of Avocado shoot tips for the conservation of Persea Germplasm
Kandeeparoopan Prasannath	PhD	AsPr Olufemi Akinsanmi	Etiology of flower blight complex in macadamia
Jane Ray	PhD	Prof Andre Drenth	Biology and epidemiology of the banana blood disease
Eugenie Singh	PhD	AsPr Elizabeth Dann	Investigating fungi causing fruit stem end rot and branch dieback in avocado
Wei-An Tsai	PhD	AsPr Ralf Dietzgen	Exploring the involvement of small RNA response in capsicum defence against capsicum chlorosis virus at elevated temperature
Yuxin Xue	PhD	Prof Neena Mitter	Propagation and genetic enhancement of Duboisia species for production of tropane alkaloids
Yunjia Yang	PhD	Dr Karishma Mody	Topical RNAi for sustainable animal health

Centre for Nutrition and Food Sciences

Full Name	Program	Supervisor	Project Title
Oladipupo Adiamo	PhD	Prof Yasmina Sultanbawa	Extraction and characterization of bioactive peptides with antioxidative and angiotensin-converting enzyme activities derived from proteins of Australian Acacia sp.
Rimjhim Agarwal	PhD	Dr Timothy O'Hare	Identification of genetic variants in orange-pigmented capsicum and chillli of the Capsicum annuum, C. chinense, and C. baccatum species
Saleha Akter	PhD	Prof Yasmina Sultanbawa	Assessing the safe use of Terminalia ferdinandiana for dietary purposes
Shanmugam Alagappan	PhD	Prof Louwrens Hoffman	Compositional analysis and Technological characteristics of Australian Edible Insects as Food Source
Batlah Almutairi	PhD	Prof Yasmina Sultanbawa	Extraction of oligosaccharides from Australian native food plants and its applications in probiotic food systems
Yeming Bai	PhD	Prof Michael Gidley	Pectin's effect on starch digestion: in vitro explorations based on molecular structure-property relationships
Eshetu Bobasa	PhD	Prof Yasmina Sultanbawa	Evaluation of urolithins obtained from ellagitannins in Kakadu plum (Terminalia ferdinandiana)
Alexander Bui	PhD	Prof Michael Gidley	Mechanisms of resistant starch breakdown by gut microbiota using high amylose wheat
Madan Chapagai	PhD	Prof Michael Gidley	Preparation and characterization of chemically modified wheat starch for selective adsorption during mineral flotation
Gengning Chen	PhD	Prof Yasmina Sultanbawa	Exploring the nutritional quality and food functionality of Burdekin plum (Pleiogynium timorense)
Selina Fyfe	PhD	Prof Yasmina Sultanbawa	Characterising the potential of the green plum (Buchanania obovata) as a native Australian fruit
Elisabet Garcia Puig	PhD	Prof Eugeni Roura	Slowing down intestinal passage rate to decrease diarrhoea risk and ZnO dependence in weaned piglets
Mingxia Han	PhD	Prof Michael Gidley	Carotenoid bioavailability related to molecular organisation
Wei Hu	PhD	Dr Timothy O'Hare	Endogenous fatty acid desaturation of palmitic to palmitoleic acid in macadamia kernel tissue.
Sera Jacob	PhD	Prof Michael Gidley	Wattle seeds for nutritional foods
Kodagoda Hitige Gethmini	PhD	Dr Michael Netzel	Assessment of the nutritional quality of Australian grown Plumcot
Haiteng Li	PhD	Prof Michael Gidley	Towards more nutritious grain: Starch structure, functional properties and nutritional functionality of high-amylose wheat
Caili Li	PhD	Prof Michael Gidley	High-amylose wheat flour as a functional food ingredient
Shiyi Lu	PhD	Prof Michael Gidley	In vitro gut microbial fermentation of models for plant dietary fibre
Michel Mubiayi Beya	PhD	Prof Louwrens Hoffman	Effects of antimicrobial and antioxidant activities of Australian native plant extracts on the safety and quality of value-added meat products
Maximiliano Muller Bravo	PhD	Prof Eugeni Roura	Amino acid balance and appetition in weaned pigs
Sharif Nada	PhD	Prof Bob Gilbert	Modelling Glycogen Structure and Metabolism
Kim Seng Galex Neoh	PhD	Prof Bob Gilbert	An investigation of late maturity alpha amylase (LMA) in wheat
Jasmine Ngo	PhD	Dr Heather Smyth	Understanding compositional-physical relationships with texture and mouthfeel of coffee mixer beverages
Thi Le Thoa Nguyen	PhD	Prof Bob Gilbert	Effect of processing steps on oat polysaccharides, their functionalities and consequent effects on quality of oat-fortified noodles
Dongdong Ni	PhD	Prof Michael Gidley	Plant cell wall architecture and molecular organisation
Adam O'Donoghue	PhD	Dr Timothy O'Hare	Assessing the bioactivity of tomato extracts from varieties with unique carotenoid profiles on human in vitro prostate cancer cell lines
Oladapo Olukomaiya	PhD	Prof Yasmina Sultanbawa	Utilization of solid-state fermented canola meal, camelina meal and lupin flour as potential protein sources for food and feed applications
Sarah Osama	PhD	Dr Glen Fox	Seed dormancy in malting barley
Apurba Lal Ray	PhD	Dr Timothy O'Hare	Genetic factors affecting anthocyanin development in purple-pericarp sweetcorn
Shammy Sarwar	PhD	Prof Yasmina Sultanbawa	Innovative non thermal technologies for treatment of fungal contamination in strawberries
Maral Seidi Damyeh	PhD	Prof Yasmina Sultanbawa	Use of novel, clean, green technologies for the extraction of plant bioactive compounds of commercial value for shelf life extension of capsicum
Zeping Shao	PhD	Prof Eugeni Roura	Phenotype and genotype association between food allergy and taste
Sukirtha Srivarathan	PhD	Dr Michael Netzel	Nutritional quality of selected Australian native fruits and Australian grown produce
Maria Stephanie	MPhil	Dr Glen Fox	Development and evaluation of wholegrain sorghum-based gluten-free pasta
Xiaoyan Tan	PhD	Prof Bob Gilbert	Structural features controlling germination and other functional properties of barley
Keyu Tao	PhD	Prof Bob Gilbert	Understanding the molecular mechanisms controlling sensory properties in starch containing foods
Saskia Urlass	PhD	Dr Heather Smyth	Australian native seaweed for diet diversification
Yujun Wan	PhD	Prof Bob Gilbert	The benefits of slowly digestible food for diabetic rats
Shaoyang Wang	PhD	Dr Heather Smyth	A systematic approach to understanding wine texture and mouthfeel
Widaningrum	PhD	Prof Michael Gidley	In vitro fermentation of insoluble dietary fibers and undigested fractions from plant food sources
Hong Yao	PhD	Prof Michael Gidley	Microbiome responses to food carbohydrates
Shaobo Zhang	PhD	Prof Bob Gilbert	Molecular Dynamics Simulation Study of Starch
Yingting Zhao	PhD	Prof Bob Gilbert	The influence of amylose in high-starch foods on biosynthesis-structure-property relations
Miaomiao Zhou	PhD	Prof Eugeni Roura	Starch and lipids in food: structural effects on brain function

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Book Chapter

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Queensland Alliance for Agriculture and Food Innovation is a research institute of The University of Queensland supported by the Queensland Department of Agriculture and Fisheries.

UQ CRICOS Provider 00025B

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