THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

QAAFI
Queensland Alliance for Agriculture and Food Innovation

Hub marks a new era in crop protection

A revolutionary alternative to chemical fungicides to protect Australia's $5 trillion global food and agribusiness sector is being spearheaded by researchers at The University of Queensland.

Led by Professor Neena Mitter, the $17.5 million Australian Research Council (ARC) Industrial Transformational Research Hub for Sustainable Crop Protection builds upon UQ's BioClay technology to create biological-based fungicides for Australian broadacre and horticultural crops.

The technology reduces chemical use, increases crop productivity, and improves sustainability across the supply chain.

Read more on page 14.

(From left) Queensland Alliance for Agriculture and Food Innovation PhD student Elizabeth Worrall, Research Fellow Dr Karl Robinson and agricultural biotechnologist Professor Neena Mitter at UQ's Gatton campus. © UQ

Queensland Alliance for Agriculture and Food Innovation

Annual Report 2019

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Drone image of researchers investigating a green plum (Buchanania obovata) tree near the Gulkula nursery near Gove in East Arnhem Land. Although eaten by the first Australians for over 50,000 years, the sweet, nutrient-rich fruit is little known by many in the bush foods industry. Read more on page 60. Image: Matthew Taylor © UQ

Revised 29 June 2020.

ABOUT QAAFI

In 2020, the Queensland Alliance for Agriculture and Food Innovation (QAAFI) celebrates a decade of delivering innovation in agriculture and food production across the supply chain.

QAAFI is an agricultural and food sciences research institute of The University of Queensland – one of the world's leading research providers in tropical and sub-tropical agriculture and food production.

We deliver high-impact science for sustainable agriculture and food – across crops, horticulture, animals, and nutrition and food sciences, and are supported by industry and the Queensland Government.

Message from the Vice-Chancellor

Building better bioeconomies

With global agriculture now on the cusp of another wave of technological revolution, many aspects of farming practice are transforming – and even our perception of food itself is changing. Thankfully, Queensland is positioned to be at the vanguard of this transformation in food production because of an historic, strategic decision made a decade ago.

That decision involved merging the research side of Queensland's Department of Primary Industries and Fisheries (now the Department of Agriculture and Fisheries) with agricultural research expertise at the University of Queensland (UQ), to create the Queensland Alliance for Agriculture and Food Innovation (QAAFI).

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.

With the global population projected to be nearing 10 billion by 2050, there is a pressing need to rapidly boost food production in order to support this population growth. This will require a range of incremental initiatives, as well as systemic change to enable climate adaptation and drive sustainable productivity improvements in food production.

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

It is positioning Australian agriculture to not merely withstand the pressures of climate change, pests, diseases, diminishing land and water resources and a rising global population, but to use these existential challenges as the catalyst for redefining agriculture as we know it.

QAAFI's success over the past decade is due to the endeavour, commitment and innovative spirit of its people. I would like to pay tribute to the entire team for their important, high-impact scientific research. And I would especially like to acknowledge Professor Robert Henry, QAAFI's founding Director, who will step down from this leadership role in 2020, having successfully guided the development of the Institute into the global research powerhouse that it is today.

Professor Peter Høj AC
Vice-Chancellor and President
The University of Queensland

QAAFI: Delivering
IMPACT

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

Income

$46 million
Total external 2019

$354 million
Total contracted

$610 million
Total projected income to 2025

People

403 People 2019

35 Higher degrees awarded 2019

113 Higher degrees awarded since 2014

Engagement

394 Active projects 2019

245 Industry presentations 2019

14 Facilities in Queensland and China

Rankings

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

#1 in Agriculture in Australia*

#5 in Agriculture in the world*

#1 in Agriculture in Australia 2020#

#25 in Agriculture in the world 2020#

**NTU Performance Ranking of Scientific Papers for World Universities, 2019*

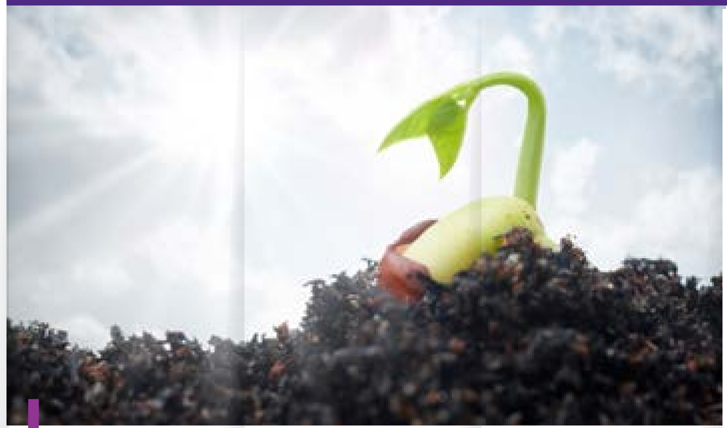
#QS World University Rankings by Subject

QAAFI

10 years of innovation in agriculture and food

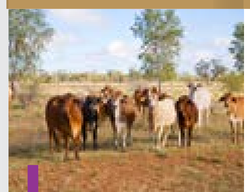
The University of Queensland Australia

Queensland Government



2010

QAAFI's Head Agreement 2010 is signed on 25 March 2010. The Research Agreement between the State of Queensland and The University of Queensland for QAAFI is executed on 25 August.



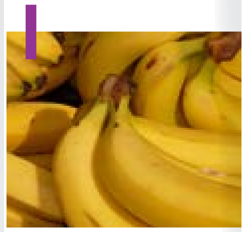
QAAFI's Centre for Animal Science and the Centre for Plant Science are established.

2011

QAAFI is a participant in ARC Centre of Excellence in Plant Cell Walls.

QAAFI becomes a collaborator in the 'High Fibre Grains Cluster'.

Banana Plant Protection Program initiated to help protect Australia's banana industry against diseases such as Panama TR4.



World's first vaccine against Bovine Viral Diarrhoea Virus (BVDV) developed with nanotechnology.

2012

Professor Robert (Bob) Gilbert is among the first foreign appointees of China's "1000 experts".

Professor Graeme Hammer is awarded the Farrer Memorial Medal in 2012 – and in 2013 is awarded the Australian Medal for Agricultural Science.

2013

QAAFI becomes an independent enrolling unit, with 70 research higher degree students joining the Institute.

QAAFI's peer-reviewed journal articles number reaches over 300. The Institute also generates over $100 million of contracted research funding.

QAAFI awarded $4 million funding by the Bill & Melinda Gates Foundation to improve sorghum productivity under drought conditions.

Three years after QAAFI's establishment, UQ's World Ranking in Agriculture Research, as measured by the NTU Performance Ranking of Scientific Papers for World Universities, jumps from 25 to 12.

2014

QAAFI is a participant in the $22 million ARC Centre of Excellence for Translational Photosynthesis.

More than half of QAAFI's articles and reviews are now written with an international co-author.

QAAFI enrols its 100th Research Higher Degree student.

2015

The Queensland Government and UQ sign a new Head Agreement to continue ongoing QAAFI funding.

QAAFI contributes more than seven per cent of UQ's research income and supervises 2.4 per cent of the University's Research Higher Degree students.

QAAFI hosts the inaugural TropAg conference, featuring 450 registrants, 300 papers, which generates research collaborations estimated to be worth between $100,000 and $1 million.

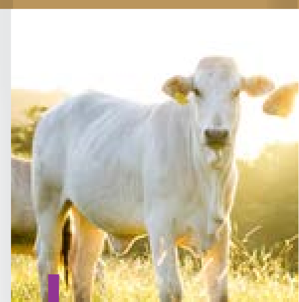
2016

Expert Advisory Board established to provide strategic advice on QAAFI's research direction.

QAAFI staff move into their first purpose-built headquarters, located in the Queensland Biosciences Precinct.

$3.8 million grant from Bill & Melinda Gates Foundation to evaluate and improve breeding programs in developing countries.

$US5.7 million funding from Bill & Melinda Gates Foundation to tackle banana bunchy top disease.



The Northern Beef Collaborative Partnership is formed between MLA and UQ.

In six years, QAAFI has grown to 450 people, including 238 higher degree students supervised to date, and has collaborations with more than 200 Department of Agriculture and Fisheries employees.

2017

Four new macadamia cultivars released to industry by QAAFI, DAF and Hort Innovation.

World-first stem cell multiplication method to radically increase avocado production announced by the Queensland Government.

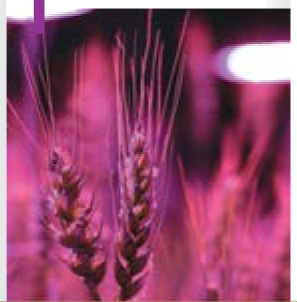
The Queensland Government's AgFutures conference is incorporated into the international TropAg conference attracting 720 attendees from 49 countries.

Professor Neena Mitter is appointed inaugural Director of QAAFI's Centre for Horticultural Sciences, to commence operations on 1 January 2018.

2018

UQ ranked first in agriculture research in Australia and fourth globally by the National Taiwan University (NTU).

Speed breeding protocols for glasshouse and growth chamber-based approaches published in *Nature Protocols*.



QAAFI contributes 17% of UQ's total industry research income and 11% of UQ's total international research income.

$14 million National Horticultural Tree Genomics Program established.

The Animal Welfare Collaborative established.

QAAFI supervises 307 Higher Degree Research students.

2019

UQ ranked #1 in Food Science and Technology by ShanghaiRanking's Global Ranking of Academic Subjects

UQ secures a $35 million ARC Centre of Excellence for Plant Success in Nature and Agriculture.

$17.5 million ARC Industrial Transformational Research Hub for Sustainable Crop Protection.

QAAFI researchers move into a new Digital Agriculture facility at UQ's Gatton campus.

Launch of the ARC Industrial Transformation Training Centre for Uniquely Australian Foods.

Nourishing Australia: a decadal plan for the science of nutrition launched.

2020

$7.9 million investment by GRDC over 10 years investment in the sorghum core pre-breeding program led by Professor David Jordan since QAAFI began has leveraged $51 million for the Australian grains industry

QAAFI's partnerships span 95 countries.

Bill & Melinda Gates Foundation fund a multi-million dollar international research collaborative, Hy-Gain, to boost hybrid vigour in sorghum and cowpea.

QAAFI's total revenue actual and projected to 2025 is $610 million.

L-R Hon Minister Mark Furner with Professor Robert Henry, David Pugh and Professor Bronwyn Harch, presents an Eat Qld Champion award to David Pugh, Executive Chef at the Brisbane Convention and Exhibition Centre at TropAg on 12 November 2019.

Message from the Minister

Science to grow Queensland

The agricultural and food industries are fundamental to the Queensland economy.

In 2019–20, the total value of Queensland's primary industry output and first-level processing was around $17.8 billion.

Queensland offers a clean and green environment that produces premium quality, fresh, safe and sustainably produced foods. The state's tropical and sub-tropical climate provides ideal growing conditions and consistent strong yields of quality produce to support food production needs.

However, the agribusiness and food sector faces change at an unprecedented scale and pace—from consumer trends, digital disruption and population growth, to the loss of fertile land and climate change.

In the next five years we will see significant change in the way we grow, produce, harvest, distribute and consume food and fibre.

These changes will challenge us to produce more value with constrained resources, while enhancing the sector's contribution to the health, trade balance, prosperity and sustainability of Queensland communities.

To meet these challenges, Queensland food and agribusinesses are supported by our state's strong record in research, development and innovation.

We collaborate with the world's best scientists and embrace innovation.

Agri-Science Queensland within the Queensland Department of Agriculture and Fisheries managed an investment of over $127 million last year on innovative research, development and extension services to enhance agribusiness productivity.

A key collaborator in this effort is The University of Queensland, through the Queensland Alliance for Agriculture and Food Innovation—or QAAFI, as it is known.

QAAFI is a global powerhouse of agricultural innovation.

The alliance of government, industry and research that QAAFI represents provides Queensland with access to a globally connected research, development and extension capability that is able to draw upon the best available scientific evidence to address the key challenges facing the sector.

QAAFI is central to what makes Queensland's agricultural and food R&D capability among the world's best, helping our industry meet the challenges and harness the opportunities to grow future food, fibre, energy and bio-products.

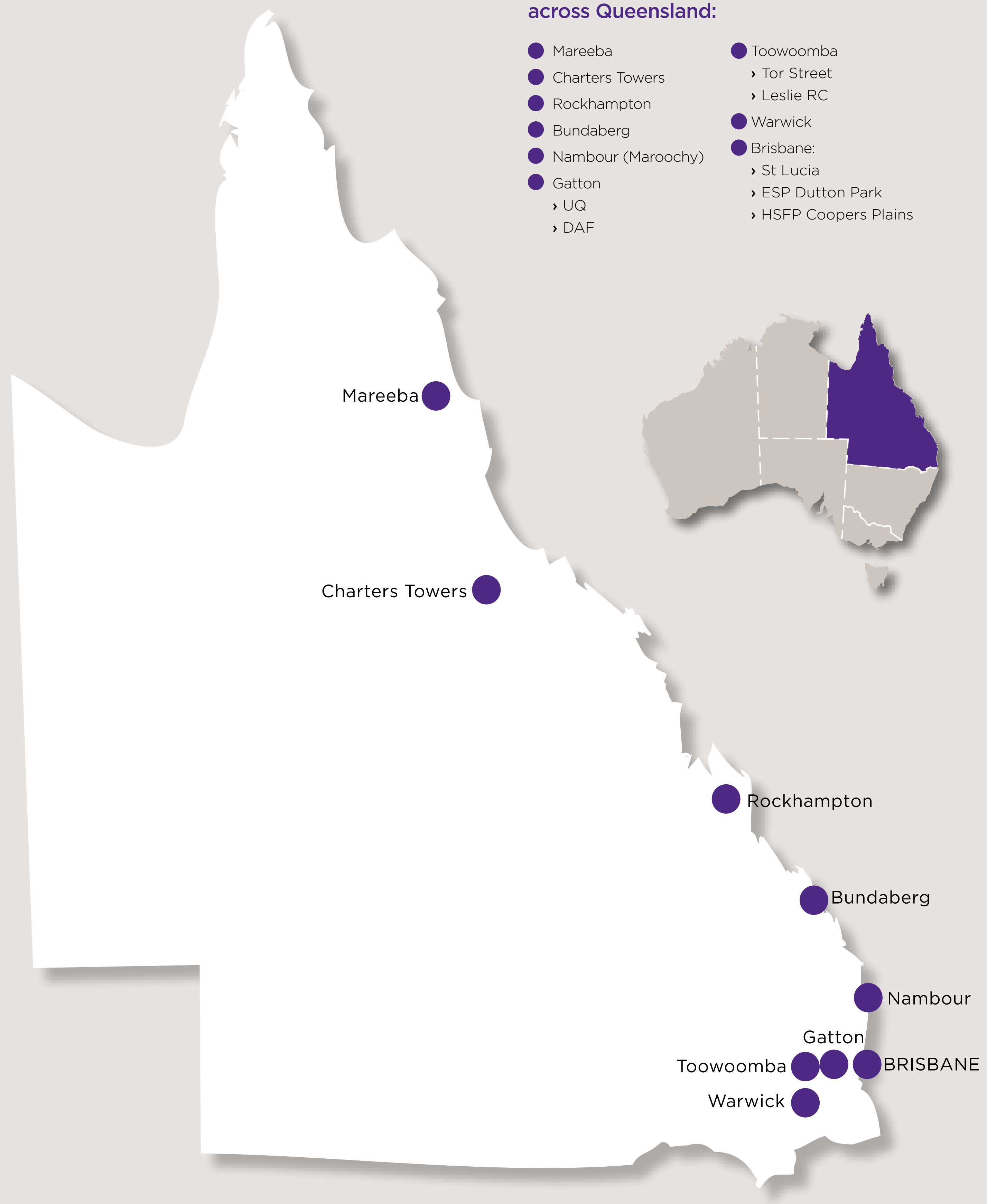
I congratulate the QAAFI team and Professor Robert Henry on their many successes over the past decade.

Honourable Mark Furner MP Queensland Minister for Agriculture Industry Development and Fisheries

QAAFI in Queensland

Our researchers are located across Queensland:

- Mareeba
- Charters Towers
- Rockhampton
- Bundaberg
- Nambour (Maroochy)
- Gatton
  - UQ
  - DAF
- Toowoomba
  - Tor Street
  - Leslie RC
- Warwick
- Brisbane:
  - St Lucia
  - ESP Dutton Park
  - HSFP Coopers Plains



Professor Robert Henry (right) was Chair of the TropAg 2019 conference, which featured leading international keynote speakers Dr Lawrence Haddad of the Global Alliance for Improved Nutrition (GAIN) and Professor Usha Zehr, Director and Chief Technology Officer, Maharashtra Hybrid Seeds Company Private Limited (Mahyco)

Professor Robert Henry

Director's message

Meeting the challenge

The business of agriculture and food production is dramatically changing, and QAAFI is positioned to be a major driver.

While in its first 10 years, QAAFI achieved many milestones that gained international attention and support, everything is dwarfed by what will emerge from disruptive technologies – genetics, nano materials and sensors, artificial intelligence (AI) and automation, and the 'big data' collected and utilised by these technical advances.

Modern agriculture encompasses just about every field of science. This multidisciplinary approach to addressing challenges and pursing new technologies, systems, products and industries could aptly be described as being the QAAFI DNA.

Over the course of its first decade, QAAFI has developed strong international linkages with research collaborations across the globe; an exemplary example being the sorghum breeding research in Australia and sub-Saharan Africa undertaken with the Bill & Melinda Gates Foundation. It highlights the global connectedness of agricultural science.

While the African farmers are still largely subsistence farmers, the underlying issues they face are the same as those faced by Australian growers. We have shown how the same R&D benefits both systems, which extends to many other sub-tropical crops. By thinking local, we are actually acting globally – and vice-versa.

My tenure as Director finishes in August 2020 when I will return to active research.

I am excited by the vast opportunities that QAAFI has opened up for agricultural science in Queensland and internationally, and strongly believe that young people seeking to have a positive impact on the world can achieve this through agriculture.

My future science work will continue to encompass horticultural tree crop genomics, helping the sugar industry diversify into new products, exploring new foods, and advancing rice as a major sustainable industry for the high rainfall regions of northern Australia.

In addition, I will take up a research role with the new ARC Centre of Excellence for Plant Success in Nature and Agriculture, which seeks to map the untapped genetic resources of native plants.

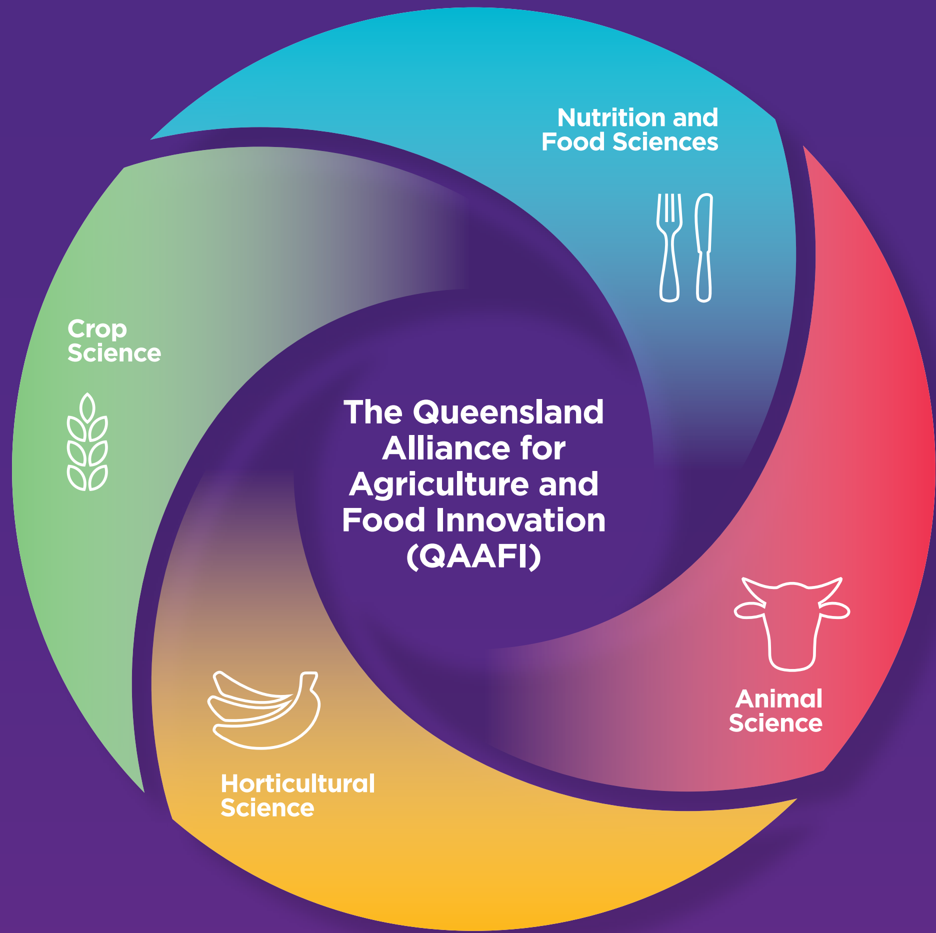
While I look forward to these challenges, my proudest achievement has undoubtedly been the opportunity to grow QAAFI, from its beginnings in 2010 when 34 agricultural scientists from the Queensland Government joined QAAFI to work directly with University of Queensland scientists, to the agricultural research powerhouse the Institute is today – an Institute comprising 400 staff, with a total projected of $610 million to 2025.

None of this would have been possible without the efforts of our staff and support of our UQ, industry, government and research collaborators – to whom QAAFI's success really belongs.

I thank you.

Professor Robert Henry, Director, QAAFI

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

Research excellence

ARC Hub for Sustainable Crop Protection

The Australian Research Council (ARC) has announced $17.5 million funding for BioClay, a revolutionary alternative to chemical fungicides, to protect Australia's $5 trillion global food and agribusiness sector.

QAAFI's Professor Neena Mitter says the newly established ARC Industrial Transformational Research Hub for Sustainable Crop Protection will build on UQ's BioClay technology to create a 'smart' form of biological crop protection.

"We will be bringing biological-based fungicides to Australian broadacre and horticultural crops, resulting in reduced chemical use, increased crop productivity, and improved sustainability across the supply chain," she says.

"This technology involves topical application of RNA interference using clay particles as carriers.

"There is no genetic modification and the clay is completely biodegradable."

Professor Mitter says that meant the BioClay would not result in chemical residues in food or runoff into waterways.

"Globally, an estimated 40 per cent of food grown is lost to crop pests and pathogens."

Led by QAAFI, the hub involves staff from the Australian Institute of Bioengineering and Nanotechnology, School of Agriculture and Food Sciences, School of Chemistry and Molecular Biosciences, School of Chemical Engineering, and Centre for Policy Futures.

"The hub comprises an expert multidisciplinary team including science, commercial and policy experts, with the aim of increasing productivity, market access and enhanced environmental credentials of Australian food," Professor Mitter says.

The BioClay Hub Partner Organisations include:

Nufarm Australia Limited; DuluxGroup (Australia) Pty Ltd; Bioplatforms Australia Ltd; AusVeg Ltd; Grains Research & Development Corporation; Cotton Research & Development Corporation; Horticulture Innovation Australia Limited; Department of Agriculture and Fisheries Queensland; Australian Wine Research Institute; South Australian Research and Development Institute; Wine Australia; Griffith University; Curtin University; La Trobe University; University of Tasmania; University of California, Riverside.

A year of achievement

Professor Neena Mitter. Photo Lyndon Mechielsen The Australian

The BioClay Hub was just one of a number of milestone achievements by Professor Mitter in 2019.

In October, she was elected as a Fellow of the Australian Academy of Technology and Engineering, in recognition for developing BioClay and her innovation in stem-cell multiplication for avocado production.

UQ Vice-Chancellor and President Professor Peter Høj AC says that as an ATSE Fellow, Professor Mitter had joined some the country's most influential innovators.

"Academy Fellows are elected on the basis of their expertise and translation of deep research into real-world outcomes," Professor Høj says.

Professor Mitter said she was honoured to be named a Fellow.

"I am passionate about delivering outcomes that enhance agricultural productivity in strong partnership with industry," Professor Mitter says.

"Along with a wonderful team of staff and students, I am focused on developing clean technologies for the agriculture of tomorrow."

Only weeks beforehand, on 11 October, Professor Mitter had been announced as winner of the prestigious Australia India Science, Research & Development Award for 2019 by the India Australia Business & Community Awards (IABCA)

The IABC Awards are Australia's largest platform dedicated to celebrating the Australia–India relationship. In 2019, the IABCA received nearly 300 applications from India and Australia.

In their citation, the judges acknowledged Professor Mitter as one of Australia's leading agricultural biotechnologists.

"Neena's career and passion for delivering real-world outcomes is informed by her Indian heritage, which recognises the significance of agriculture in shaping the world, economically, socially, environmentally and politically. She has spearheaded the development of a broad program of cross-functional innovative solutions for profitability and productivity of Australia's $60 billion agriculture industry."

L-R Professor Robert Henry, Professor Christine Beveridge, Professor Melissa Brown, Professor Peter Høj AC with Hon Dan Tehan announcing funding for the Centre at UQ on 8 October 2019

ARC Centre of Excellence for Plant Success

Federal Minister for Education Dan Tehan announced $35 million in funding to establish a research centre that focuses on plant adaptive strategies and resilience.

Professor Mark Cooper

The Australian Research Council (ARC) Centre of Excellence for Plant Success in Nature and Agriculture will be led by UQ's Professor Christine Beveridge, with QAAFI's Professor Mark Cooper serving as the Centre's Deputy Director.

"The Centre of Excellence will investigate the adaptive strategies underpinning productivity and resilience in a range of diverse plants," Mr Tehan says.

"This will deepen our knowledge of the genetic and physiological traits of plants, giving breeders unparalleled predictive capability to improve strain quality."

Professor Beveridge says the team would identify nature's success stories and translate them into opportunities to enhance yield and resilience in agricultural crops.

"By predicting the plant varieties that are best for particular environments, we can help farmers choose which plants to grow in what areas for each season for the best yield," Professor Beveridge says.

"An important component of the centre is the focus on the regulatory requirements which will allow the new technologies to be scaled globally to future-proof agriculture around the world."

Researchers from The University of Queensland will collaborate with experts at four Australian universities and 13 academic and industry partner organisations from Australia, Europe, Asia, the USA and Canada.

Together they will provide an additional $75.2 million in cash and in-kind support to the centre.

Awards cap a stellar year for Lee

UQ's pioneering speed breeding technology, initially inspired by NASA experiments to grow wheat under continuous light in space and now successfully trialled on a range of crops, has won the technology's chief innovator, QAAFI's Associate Professor Lee Hickey, the university's most prestigious research award – a UQ Foundation Research Excellence Award (UQFREA).

The University announced UQFREA award winners at the 2019 Research Week Awards.

UQ's Deputy Vice-Chancellor (Research) Professor Bronwyn Harch says the awards recognised the passion and commitment of the University's researchers and research supervisors.

Speed breeding accelerates breeding of important traits into future crops, to help combat disease, and climate change and boost food security.

Associate Professor Lee Hickey was also presented with an ICM Agrifood Award by the Australian Academy of Technology and Engineering in July 2019.

He was acknowledged for his work in plant breeding and genetics research into Australia's most important cereal crops, wheat and barley.

Associate Professor Lee Hickey © UQ

Research excellence

Industry Research Fellowship

Dr Karishma Mody
© UQ

Dr Karishma Mody was awarded a $180,000 2019 Advance Queensland Industry Research Fellowship (AQIRF) for her project *BioClay innovation: sustainable alternative to pesticides for protecting Queensland's livestock.* The Fellowships support PhD-qualified researchers in undertaking original research that will benefit Queensland, while partnering with industry. In 2015, Dr Mody won the Dean's Award for Outstanding Research Higher Degree Theses, and was a finalist in the 2013 UQ Three-Minute Thesis competition.

Outstanding paper award

Dr Alex Wu. © UQ

Dr Alex Wu's 2018 paper 'Simulating daily field crop canopy photosynthesis: an integrated software package', published in *Functional Plant Biology* (FPB), won the Australian Society of Plant Scientists (ASPS) – Functional Plant Biology best paper by an early-career researcher at the 2019 ASPS conference. The paper discusses development of a model of diurnal canopy photosynthesis for well-watered conditions by using biochemical models of C_3 and C_4 photosynthesis upscaled to the canopy level using the simple and robust sunshade leaves representation of the canopy.

Lifetime achievement recognised

Professor Ben Hayes, Director of the Centre for Animal Sciences at QAAFI was named in the 2019 Lifetime Achievement Leaderboard of 'The Australian' as one of Australia's five best performers in Life Sciences for his research in genetic improvement.

DVCR's Award for Excellence

Congratulations to Ms Bronwyn Venus, who won the Deputy Vice-Chancellor (Research's) Award for Excellence at the 2019 Research and Innovation Staff Awards.

Ms Bronwyn Venus with Professor Bronwyn Harch. © UQ

Horticultural Science excellence recognised

Dr Andre Drenth

At the Australasian Plant Pathology Society conference in November 2019, QAAFI's Professor Andre Drenth and Associate Professor John Thomas were made Fellows of the Australasian Plant Pathology Society for lifelong achievement in plant pathology. Nga Tran received the Allen Kerr Postgraduate Prize for the best piece of original research relevant to Australasia by a postgraduate student in the last two years. Dr Andrew Gearing was appointed President-elect, to become President in 2021.

NABRC medal for science

Dr Rob Dixon's internationally recognised expertise in ruminant nutrition and his significant contribution to northern Australian production systems has earned him the 2019 North Australian Beef Research Council (NABRC) Medal for Science.

Dr Dixon (pictured far left) has made a significant contribution to managing the impacts of cattle grazing the extensive rangelands of northern Australia.

Also pictured (L-R): Industry innovator Ross Peatling of 'Alexandria Station' on the Barkly Tableland was awarded the 2019 NABRC Producer Medal; Ben McGlynn, manager of Rocklands Station, received the 2019 NABRC Young Achiever Medal; and Queensland Department of Agriculture extension officer, Joe Rolfe, based in Mareeba, was awarded the 2019 NABRC Communicator/Extension Medal.

Shannon wins Zanda McDonald Award

For the first time in the five-year history of the prestigious Zanda McDonald Award, not one but two young Australian agriculturalists have been crowned as the winners.

QAAFI's Shannon Landmark, Northern Genomics Project Coordinator with the Centre for Animal Science, shared the award with Luke Evans from the Northern Territory.

Ms Landmark is a trained vet, and her work with the Northern Genomics Project focuses on improving genetic selection and reproductive technology.

The award, sponsored by Allflex, Pilatus, CBRE Agribusiness, Zoetis, MDH and Rabobank, is named in honour of the late Zanda McDonald who was a foundation member of the Platinum Primary Producer (PPP) Group, a collective of over 150 of Australia and New Zealand's top rural leaders..

Shannon McDonald. Photo: Supplied. Zanda McDonald Awards

Avocado innovators win top research award

QAAFI's Director of Horticultural Science, Professor Neena Mitter, and her research team of avocado innovators and industry collaborators took out one of UQ's most prestigious awards in 2019 – the Partners in Research Excellence Awards (PIREAs).

The PIREAs recognise outstanding models of high-impact collaborative research partnerships. The awards celebrate the achievements and successes of UQ researchers who through industry engagement, research collaboration and commercialisation have achieved excellent outcomes and national and international research impact.

The avocado team won for the world's first avocado tissue culture technology.

The team comprises Professor Neena Mitter, Dr Alice Hayward, Dr Jayeni Hiti Bandaralage, Mr Christopher O'Brien, Dr Madeleine Gleeson, Professor Christine Beveridge and Professor Bernard Carroll with Anderson Horticulture Pty Ltd, Jasper Farms, Delroy Orchards, Ausavo Corporation and the Donovan Family Investments Trust, MACKAYS and Collins farms.

Photo: Back row, L-R: Prof Bernard Carroll, SCMB, Faculty of Science; Graham Anderson, Director, Anderson Horticulture Pty Ltd; Stephen Mackay, Director, MAC Farms Pty Ltd; Leon Collins, Director, L&R Collins Pty Ltd. Front row, L-R Dr Madeleine Gleeson, Prof Neena Mitter, Dr Jayeni Hiti Bandaralage, Dr Alice Hayward. © UQ

Grains industry innovators celebrated

The inspiration, passion, innovation and success of key players in the grains industry was celebrated at the 2019 Australian Summer Grains Conference on the Gold Coast in July 2019. The Summer Grains Conference crop award winners were (back, L to R) QAAFI's Andrew Borrell (mungbean award), Andrew James (soybean award), QAAFI's David Jordan (sorghum award). Front, L-R: Col Douglas (mungbean award), Liz Alexander (sunflower award) and Harley Bligh (maize award).

Photo: Supplied by Summer Grains

TROPAG

TropAg delivers science for global nutrition and food security

The biennial TropAg conference has grown from 450 registrants in 2015, to 820 for the third conference, which was held in Brisbane, Australia, on 11–13 November 2019.

TropAg has developed into the world's premier conference for agricultural and science in tropical and sub-tropical climates in both developed and developing countries.

The conference is highly valued for its unique 'farm to fork' focus – featuring plenaries and symposia across animal, crop, horticultural, and food and nutrition sciences – and the invaluable networking and developing new partnerships the conference presents.

The TropAg program also encompasses an AgFutures stream supported by the Department of Agriculture and Fisheries in Queensland, which showcases the latest digital and on-farm innovations.

TropAg has a critical role to play in providing a platform to bring together science leaders from the 'hot zone' – the tropics and subtropics – together with future and emerging leaders, and policy-makers from some 43 countries around the world.

Our aim is to strengthen these existing international collaborations with industry and build new partnerships.

As one of only a few developed countries in the world located in a tropical environment, Australia, and particularly Queensland, have a unique place in the world for tropical and sub-tropical agriculture and food production. Queensland agriculture is at the forefront of research in this field, and TropAg's host, The University of Queensland (UQ), is recognised globally as a leader in agricultural research.

The conference was made possible by support from UQ, the Queensland Government, and 35 sponsors, trade exhibitors and media partners.

L-R: Professor Bronwyn Harch, DVCR, UQ; Professor Pamela Ronald, Founding Director of the Institute for Food and Agricultural Literacy, University of California, Davis; Professor Neena Mitter, Director, Centre for Horticultural Science, QAAFI; Tamanna Monem, Women in Business, Queensland Chapter.

TropAg2019 Snapshot

- 820 Attendees
- 43 Countries represented
- 7 Keynote speakers
- 240 Symposium presentations
- 281 Poster presentations
- 5 Themes
- 35 Sponsors

TropAg 2019 is estimated to have delivered $1.5 million in economic benefit to Brisbane and Queensland.

"We are dealing with a crux of issues including pathogens, population growth, an increase in per capita food consumption associated with growing affluence, scarcity of resources, and impacts of climate and environmental disruptions."

Professor Robert Henry, Chair, TropAg 2019

Professor Birgitte Skadhauge, Vice President, Carlsberg Research Laboratory; Dr Glen Fox, Anheuser-Busch Endowed Professor of Malting and Brewing Sciences, UC Davis

Dr Beth Woods, Director-General of the Department of Agriculture and Fisheries (left) and QAAFI Deputy Director Mr Steve Williams (right) meet a furry delegate, courtesy of Geckoes Wildlife.

TROPAG

QAAFI
TROPAG
11 - 13 NOVEMBER 2019
AgFutures
Field Crops
Livestock
Horticulture
Nutrition & Food
TROPAG
LI-COR

ANIMAL SCIENCE

Leading tropical livestock research and development

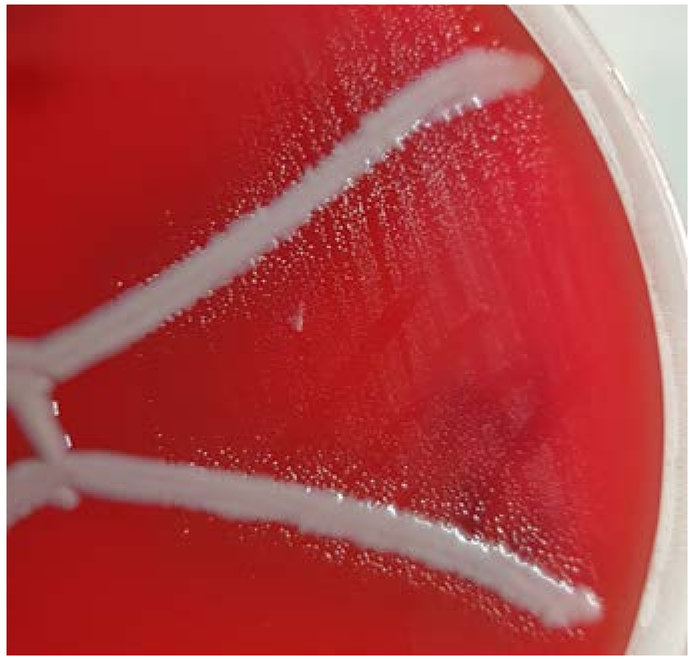
The Centre for Animal Science delivers world-class research to Australia's animal industries.

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



Glaesserella australis *on blood plate with* Staphylococcus aureus *displaying satellitism © UQ*

Costly pig lung disease puzzle solved

Dr Conny Turni's research reveals that a previously unrecognised bacterium is responsible for the signs of lung disease found in pig carcases, rather than a similar, internationally recognised infection that the animals had been vaccinated against.

Dr Conny Turni, Senior Research Fellow, Centre for Animal Science, Queensland Alliance for Agriculture and Food Innovation, The University of Queensland in the lab

Having solved the disease mystery, Dr Turni's team at QAAFI is now working to develop on-farm tests and treatments for the new infection.

Several years ago it was noticed that lesions, abscesses and pleurisy found in the lungs of pigs at abattoirs looked very similar to those associated with a known serious pig respiratory disease, porcine pleuropneumonia.

This is caused by the bacterium *Actinobacillus pleuropneumoniae*, which was assumed to be the culprit, despite the fact that animals had been fully vaccinated.

Porcine pleuropneumonia is a major economic disease that causes animals to lose weight at a critical growth stage. Previous research has shown that animals' average daily weight gain can drop by up to 20 per cent until halted by treatment, with the animals requiring an extra 20 or so days to recover. This leads to a considerable increase in production costs, or if a producer decided to sell the animals underweight, the losses could be as high as $60 per pig.

New species discovered

Australian Pork Limited put QAAFI researchers on the case. They discovered one new species and another potential new species of lung-infecting bacteria, which put to rest concerns that current vaccines simply weren't working.

Project leader Dr Conny Turni says that when the unexplained signs of disease were found, it was in the same growth period in which porcine pleuropneumonia caused by *Actinobacillus pleuropneumoniae* occurs.

However, the pigs are vaccinated for this so there could be only two possibilities: either the vaccines weren't working, or there was another pathogen at work causing a similar disease or in some way interfering with the efficacy of the vaccines.

"We had been storing isolates from some diseased pigs but hadn't been able to identify them until a couple of years ago when we had two master's students work on them, and they determined that a number of these isolates represented a new bacterial species," says Dr Turni.

However, the researchers couldn't continue the formal process of describing and naming the new species because the discovery occurred at the same time that the closest known relative to the new organism, *Haemophilus parasuis*, was being renamed *Glaesserella* by US researchers.

Once the new genus was formally recognised in 2019, the QAAFI researchers could announce *Glaesserella australis* as a new species.

On-farm effects

Dr Turni says *G. australis* is associated with two disease scenarios. One is where there are no apparent clinical signs of disease on-farm, but at the abattoir the carcase has lesions and abscesses in the lungs that are very similar to those caused by *Actinobacillus pleuropneumoniae*.

In the other disease scenario *G. australis* causes clinical signs in pigs on-farm, at 12 to 20 weeks of age, with some cases being fatal.

Dr Turni says continuing research into *G. australis* has led to a diagnostic assay that is currently being validated. This involves testing 26 *G. australis* isolates, 15 reference strains and one field isolate of *A. pleuropneumoniae*, 16 reference strains for another bacterium (*Pasteurella multocida*) that causes respiratory disease, and another 47 strains and field isolates representing 12 genera and 26 species of similar bacteria.

To determine the prevalence of *G. australis*, the researchers sampled lungs with lesions, abscesses and pleurisy from 23 farms in NSW, 43 in Queensland, one in SA and 27 in Victoria. This data is still being analysed.

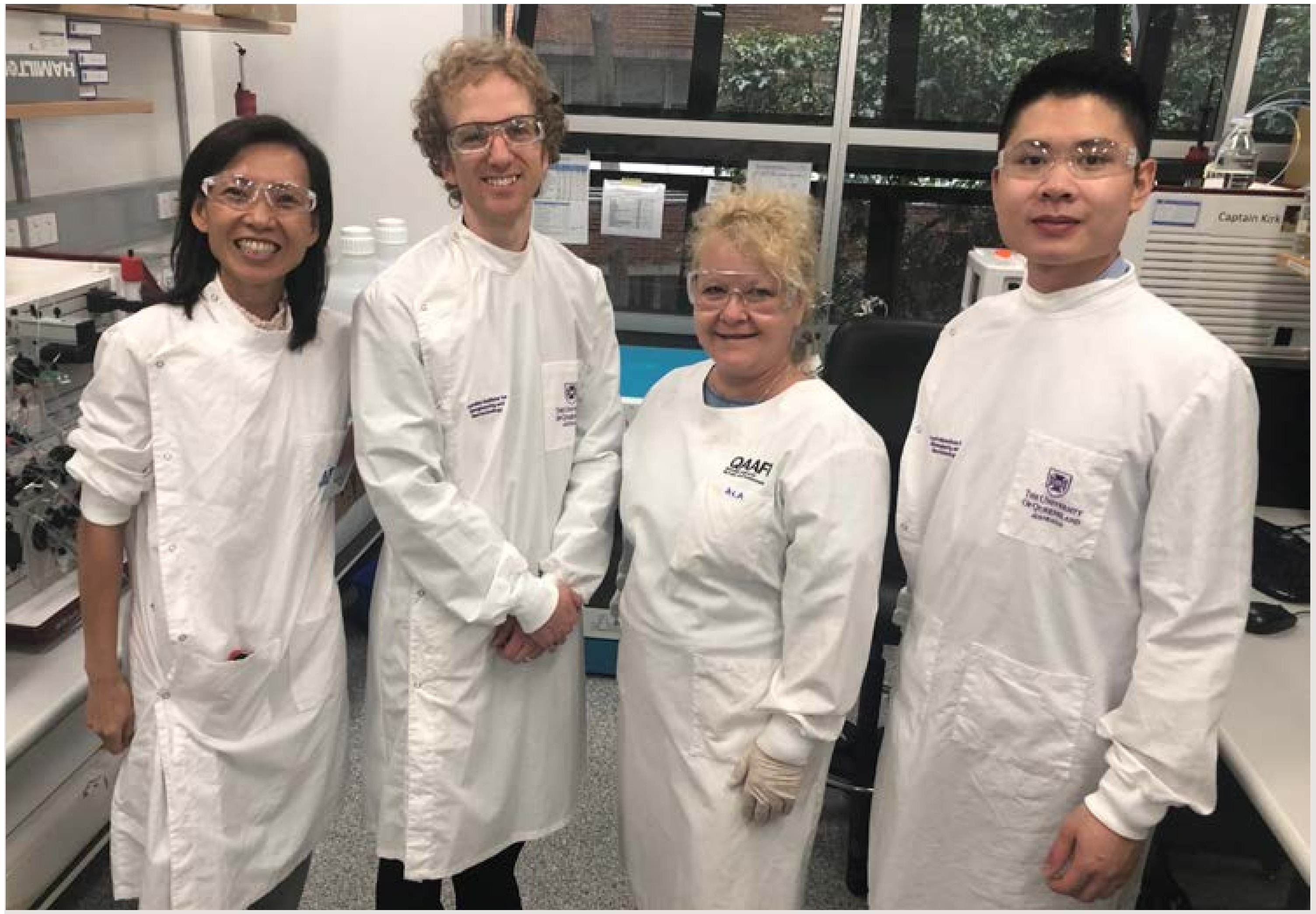
For future on-farm diagnosis, the QAAFI team is investigating the potential for nasal and tonsil swabbing to see if this will detect the bacterium in live pigs, which would simplify control and management of the disease.

Another part of the project is examining methods to determine the antimicrobial sensitivity profile of *G. australis* isolates to help the industry develop targeted, effective treatment programs.

Manager, Production Innovation at Pork Australia, Rebecca Athorn says the discovery of *G. australis* delivers both animal health and economic benefits for the industry.

"The judicious use of antimicrobials and antibiotics is an industry priority. This discovery, and the development of an assay to test for this particular bug, allowing targeted treatment, is significant to the industry's efforts overall to increase vaccine efficiency," she says.

This research is funded by Australian Pork Limited and the Department of Agriculture and Fisheries.



Cattle tick - Image courtesy Ala Tabor

Prof Tabor with the UQ's Protein Expression Facility (PEF) team, demonstration of their scale up of cattle tick vaccine recombinant antigens for current cattle trial. L-R Prof Linda Lua (Director of PEF), Chris Munro, Ala Tabor, Ric Tang. © UQ

Hereford cattle in the tick trial © UQ

Tick vaccine for *Bos taurus* breeds a step closer

A vaccine to protect Bos taurus *breeds from the costly cattle tick is getting closer, paving the way for northern producers to introduce genetics capable of opening doors to new, high-value markets.*

To help solve the annual $175 million cattle tick problem, QAAFI researcher Professor Ala Tabor and her international team have investigated what makes *Bos indicus* cattle immune to the effects of cattle ticks, and whether that knowledge can be used to make a vaccine to protect the susceptible *Bos taurus* cattle using reverse vaccinology.

Cattle ticks (*Rhipicephalus (Boophilus) microplus*) were introduced to Australia in 1872 and quickly became endemic within the zone where temperature and humidity support the tick's lifecycle year-round. Although they were found in Victoria in 1914, they cannot survive winter outside the tropics and sub-tropics, and the ticks never became endemic.

Bos indicus cattle have a natural immunity to cattle ticks but *Bos taurus* cattle are highly susceptible, making cattle tick one of the driving forces behind cattle breed decisions in Northern Australia and throughout the tropical zones of the world.

Heavy infestations of ticks cause ill-thrift due to loss of blood and 'tick bother', the continual discomfort of parasitism. Ticks are also the vector for the three pathogens (two parasites and one bacterium) that cause tick fever, which results in illness and often death in cattle.

There are several mechanisms in place to manage cattle ticks in Australia. The first is the 'tick line', a biosecurity measure used to restrict and monitor the movement of cattle between the tick and tick-free zones. In the tick zone, many producers choose to run cattle with a high content of *Bos indicus* genetics, typically at least 3/8 Brahman, to reduce the effect of ticks and the cost of management. Producers within the tick zone who want to run cattle with higher *Bos taurus* genetic content need to regularly treat their cattle with araricides.

In 1994, an Australian tick vaccine was released commercially as TickGARD but industry uptake was low and distribution of the live vaccine ceased in 2010. The use of this vaccine proved largely impractical in northern Australian cattle production systems as protection was provided only when cattle were injected with vaccine boosters at intervals through the year. In extensive pastoral operations it is uncommon for cattle to be mustered more than once or twice a year; however, the development of novel adjuvants may extend vaccine duration. In several countries, the vaccine was ineffective against local tick strains, which led to this research program to discover new vaccine targets.

The development of a viable vaccine option for the Australian and international beef industry was the aim of an extensive Beef CRC research program (2005–2012) led by Professor Tabor. The research program identified and tested a range of vaccine components and mixtures including short protein peptides, some mixtures of short peptides, and whole large proteins.

Achieving this can be summarised in five major steps:

1. Find out what ticks inject into their host when they attach. These are the antigens.
2. Find out what confers resistance in *Bos indicus* cattle. These are the antibodies.
3. Look at the specific sequences that confer resistance to identify the parts of the proteins that bind with antibodies that deactivate them and confer protection.
4. Study resistance responses in cattle during different life stages of the tick. Determine if the antigens are produced by multiple tick life stages and organs of the adult female tick (thus all stages contributing in boosting protection – making antibodies that will repel the tick.
5. Feed about 2500 adult female ticks with blood containing different antibodies to target specific antigens and study the effect on egg production, larvae growth and development.

In vivo tick challenge vaccine cattle trials providing results of 42-73% efficacy with mixtures of antigens.

Of these anti-cattle tick antigens identified, approximately 20 vaccine individual components were tested in cattle trials (B.AHE.0212) and achieved efficacies of up to 66 per cent. To date, no synergistic effects were found through mixing different components.

Current research aims to obtain long-term efficacy of over 80 per cent to support commercial use of a tick vaccine in the extensive pastoral zones. This involves the development of a vaccine either using a proprietary mixture of the four most effective peptides or their whole protein derivatives currently under trial testing.

Acknowledgements (MLA: B.AHE.0024; B.AHE.0212): Ala Tabor, Manuel Rodriguez Valle, Michael McGowan (UQ), David Mayer, Elizabeth Fowler, Catherine Minchin and Bing Zhang (QDAF).

Patent inventors: Prof Ala Tabor, Prof Manuel Rodriguez Valle (previously QDAF), Prof Matthew Bellgard (previously Murdoch University), Dr Felix Guerrero (USDA).

The research is currently supported by Queensland Department of Agriculture and Fisheries, Meat & Livestock Australia and The University of Queensland, with previous support from Murdoch University, the US Department of Agriculture, the CRC for Beef Genetic Technologies and a Queensland Smart State Grant: NIRAP – National International Research Alliance Program.

Beef CRC © QAAFI, UQ

Beefing up against cattle disease

A Bovine Respiratory Disease (BRD) prototype vaccine that targets multiple pathogens is under commercialisation, to help curb the up-to $100 million a year impact of BRD on Australia's beef industry.

Professor Tim Mahony

Approximately one million cattle in the Australian beef industry are contained in feedlots, where they are fed a controlled diet so they satisfy meat industry requirements.

The Australian cattle feedlot industry is relatively new, and growing at a rapid rate.

But BRD is curbing that growth and causing national losses of up to $100 million a year.

"BRD is caused by a combination of three factors – stress, a viral infection, and a bacterial agent – and is most commonly found in domestic feedlot cattle," says QAAFI's Professor Tim Mahony.

"Cattle may experience stress in a range of situations, including when they're handled, transported, introduced to new cattle, or exposed to new environments.

"This stress can depress their immune system, making them more susceptible to BRD."

The symptoms of BRD resemble those of the flu in humans – dull eyes, decreased appetite, breathing difficulty, droopy ears and depression – and can be fatal.

It is a major concern for feedlot operators and cattle producers in the North American industry and, despite years of research, there has been little success in reducing its impact.

The Australian feedlot industry has an advantage however – because it's younger and smaller, researchers and producers have been working together to manage BRD as the sector is growing, rather than retrospectively trying to control the problem after it has become unmanageable.

Historically, testing the effectiveness of new vaccines has been relatively simple – administer the vaccine or treatment to a population, expose them to the virus of interest, and monitor their health.

As these vaccines generally do not prevent infection, the differences between vaccinated and unvaccinated animals can be small.

Consequently, these experiments require large numbers of animals to determine whether the vaccine is effective.

Professor Mahony and his team therefore developed the dual-pathogen challenge model, a technique testing the effectiveness of the vaccine by accentuating clinical signs severity in unvaccinated versus vaccinated individuals.

However, because the model lacks the third component of BRD development – stress – trial animals do not develop severe or fatal disease.

In trials completed with the assistance of staff at the Queensland Animal Sciences Precinct at UQ's Gatton campus, vaccinated and unvaccinated cattle were sequentially exposed to challenges with viral and bacterial agents associated with BRD.

The team then evaluated how effective the vaccine was by looking at the severity of BRD symptoms in the cattle. Unvaccinated cattle demonstrated mild BRD symptoms, while vaccinated cattle had even milder or no symptoms from the bacterial infection.

"The secondary bacterial challenge component means the unvaccinated animals develop only a mild clinical disease like coughing or lethargy, but we don't see many, if any, of these signs in the vaccinated individuals," Professor Mahony says.

"The clinical differentiation between the treatment groups is far more distinct and robust (in comparison to traditional vaccine trials), which ultimately means we can use fewer animals in the trials to generate more meaningful results.

"We believe the dual-pathogen challenge model will translate into improved and sustained disease control in the field."

This is only the beginning of the BRD vaccine journey for Professor Mahony and his team.

They hope to identify other pathogens that are involved in the onset of BRD in Australia, and extend the scope of their current BRD vaccine platform as far as possible for feedlot cattle.

The team is also keen on taking advantage of the platform given to them by a commercial partner to tackle BRD on an international scale, where annual losses are currently estimated at $2.5 billion.

A critically important outcome of preventing BRD will be a reduction in the use of antibiotics to treat affected cattle.

The vaccine will also immensely benefit those who breed cattle for extensive raring or for sale into the feedlot sector.

While the cattle-producing sector is a separate beast to the feedlot sector, both industries face productivity losses due to the pathogens associated with BRD; with the former losing an estimated $115 million in Australia each year in reproductive losses due to bovine pestivirus, also commonly linked to BRD.

While the use of the vaccine in non-feedlot systems will probably occur in a different time frame, the vaccine has the potential to revolutionise the beef industry.

"Better vaccines are crucial to improving the long-term profitability and sustainability of Australia's livestock industries, which lose over $3 billion annually to pests and diseases," says Professor Mahony.

Progress to date:

- **1998:** Industry recognises new approaches are required to address Bovine Respiratory Disease
- **2002:** Professor Mahony and team develop a vaccine delivery platform capable of targeting multiple pathogens at once
- **2002:** Professor Mahony and team lead discussions with industry to communicate their research results
- **2004:** Professor Mahony and team successfully construct a prototype vaccine
- **2004:** The team files and is awarded a patent on the vaccine technology – this primary and protected position was crucial for potential partners
- **2005:** Professor Mahony and his team develop a multifaceted dual pathogen challenge model to evaluate vaccine effectiveness
- **2007:** The team consult widely with veterinary pharmaceutical companies to understand their expectations in new technologies
- **2007–2015:** Trials demonstrate the prototype vaccine effectiveness using a dual-pathogen challenge model
- **2007–ongoing:** Consultation with relevant regulatory authorities regarding a new type of vaccine
- **2015:** The team is awarded the patent on the vaccine technology in Australia and other jurisdictions, while the patent for the United States is in final stages
- **2016:** Commercial partner is identified to progress the prototype vaccine through to registration
- **2017:** Contractual negotiations undertaken for the licensing of the prototype vaccine to commercial partner
- **2018–19:** Planning to transfer prototype vaccine to commercial partner for further development and evaluation

Acknowledgements: *The Queensland Alliance for Agriculture and Food Innovation (QAAFI) is a research institute of The University of Queensland (UQ), supported by the Queensland Department of Agriculture and Fisheries. This research is funded by UQ, the Queensland Department of Agriculture and Fisheries, Meat and Livestock Australia, with matching funds from the Australian Government and grant projects B.FLT.0203, B.FLT.0224 and B.FLT.0232.*

Dr Luis Prada e Silva © UQ

Brahman cattle © Shutterstock

Tail hair testing to select cattle for low-quality pastures

Identifying traits in cattle that allow them to thrive in challenging environments is the aim of new research to assist Australia's northern cattle producers.

Tail-hair samples routinely used for DNA testing in cattle are also providing valuable information about the ability of Brahman cattle to survive on the low-quality pastures typical in Australia's northern regions.

Being able to identify this adaptability trait is expected to help northern producers identify bulls that will produce offspring better suited to the local environment.

QAAFI livestock nutrition expert Dr Luis Prada e Silva is investigating the ability of animals to adapt to pasture-based diets, which are often low in protein, as part of efforts to improve animal performance.

A key trait that Dr Prada e Silva is focusing on is the ability of cattle to recycle nitrogen when challenged by low-protein diets.

This ability is a unique evolutionary trait of ruminants such as cattle, and has implications for animal growth, fertility and calf survival.

Nitrogen is essential for the rumen microbes, which effectively produce additional protein for the animal. When cattle eat low-protein diets, nitrogen is normally lost in urine. But on higher quality diets, nitrogen is recycled to the rumen to mitigate any shortfall.

Dr Prada e Silva says herds across northern Australia might graze pastures that are eight per cent protein in the growing season, dropping as low as three per cent for extended periods during other times of the year. By comparison, feedlot cattle diets are generally 13 per cent protein.

His research is comparing the performance of Brahman cattle, supplied from the Simon Cattle Company at May Downs, Central Queensland, on high- and low-protein diets (13 per cent and 8.5 per cent, respectively), although he points out the 'low' is still quite high compared to common pasture conditions.

Having tested 60 animals so far, he says there has been no correlation in the performance of cattle on high- and low-protein diets in terms of either growth or feed efficiency.

"We have effectively demonstrated that selecting genetics from high-performing, well-fed stud bulls will not translate to a similar growth performance for progeny feeding on low-protein feed," Dr Prada e Silva says.

One of the key research findings has been the identification of nitrogen isotopes in the animals' tail hair that indicates the ability of cattle on low-protein feeds to recycle nitrogen within their own bodies.

"We've used a forensic science approach to identify changes in the signature of the isotopes. Changes in the composition of the nitrogen isotopes have a strong correlation with feed efficiency and growth on low-protein diets, making it a useful marker to identify this nitrogen recycling ability."

However, he says these changes manifested only when there was a protein shortfall in the diet, making it difficult to predict the performance of well-fed animals, should there be a change in their diet.

The ultimate goal is to develop a fast, crush-side test that producers can use to sort and select animals that will perform in tough conditions.

The project started in 2018 and will run until 2021, with another 30 animals to be diet-tested before it finishes. The project is jointly supported by the Department of Agriculture and Fisheries, The University of Queensland, and Meat and Livestock Australia Donor Company.

Dr Prada e Silva and his team are also investigating the mechanisms that trigger nitrogen recycling and its impact on rumen microbes, carcase composition, and potential genetic markers for this nitrogen recycling ability.

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

Members of the Hy-Gain research team at UQ's Crop Research Unit at Gatton: (Back) Mr Basam Tabet, Professor David Jordan, Dr Emma Mace and Professor Ian Godwin from QAAFI.

The plant breeders' dilemma: sex or no sex?

The ability to switch between sexual and asexual modes of reproduction in plants is being exploited to help some of the world's poorest crop farmers.

Professor Anna Koltunow

By exploiting quirks in plant reproduction, an international team of researchers funded by the Bill & Melinda Gates Foundation and headed by Professor Anna Koltunow of The University of Queensland are seeking to improve the bottom line for farmers.

The endgame is to increase yields and hardiness while reducing on-farm costs thereby improving agricultural productivity, profitability and food security.

First in line to benefit are poor smallholder farmers in sub-Saharan Africa who rely on exceptionally drought-tolerant and hardy crop species to survive.

Of prime importance are sorghum and cowpea, domesticated in Africa, and important subsistence food crops.

Because hybrids – the offspring of in-bred, genetically divergent parents – can be exceptionally tough and highly productive, they are the initial focus of this work.

Professor Koltunow explains that significantly higher yield gains are possible by cultivating hybrids, with both sorghum and maize routinely cultivated commercially in this way.

The downside for farmers is that this yield-boosting hybrid vigour – technically known as 'heterosis' – is expressed only in the first generation of progeny.

"Hybrids are valuable to agriculture but the benefit is offset by the cost to the farmer of purchasing hybrid seed every year," Professor Koltunow says.

"For smallholders to benefit from hybrids, the new breeding method we are developing will allow farmers to retain and re-sow hybrid seed for multiple generations."

The right expertise

Professor Koltunow has a formidable record of accomplishment in plant reproduction research and translating that research into gains in agricultural sectors.

Her research focus is on the molecular and genetic mechanisms that regulate development of plant reproductive cell types and, therefore, seed and fruit formation. Accomplishments include developing seedless fruit, a sought-after commodity in the horticultural sector.

She was selected by the Bill & Melinda Gates Foundation to head an international collaborative research venture between six research organisations and a multinational seed company to develop technologies so smallholder African farmers could economically save seed from cowpea and sorghum hybrids.

Cowpea seeds. Cowpea (Vigna unguiculata) is an annual legume and important protein-rich source of food for humans, and used as feed for livestock. It fixes nitrogen in soil and is often intercropped with sorghum on smallholder farms
Photo: © Susan Johnson

Professor Koltunow led the first five-year phase of this project, called Capturing Heterosis, while at CSIRO. This project finished in July 2019 and the second phase, also funded by the Bill & Melinda Gates Foundation – Hy-Gain – commenced in March 2020, at the University of Queensland.

Professor Koltunow, who in 2019 took up a Professorial Research Fellow role at QAAFI will again lead the project.

The Hy-Gain team includes QAAFI's world-leading sorghum researchers, Professor David Jordan, Dr Emma Mace and Professor Ian Godwin, who have expertise in breeding, genetics and transformation.

Associate Prof Brett Ferguson from The University of Queensland's School of Agriculture and Food Sciences (SAFS) is contributing leading expertise in legume biotechnology.

These researchers are linked to five prestigious international research institutes and a multinational seed company, which collectively form Hy-Gain – a public-private research team to promote food security in the developing world. The five-year project includes in-kind funding from several of the participating institutions.

"Together, the Hy-Gain project team is developing new ways to breed sorghum and cowpea varieties that make it possible to achieve large gains in yields, while increasing resilience to diseases and environmental stress," says Professor Koltunow.

The key to preserving intergenerational hybrid vigour lies with one of the quirkiest aspects of plant sexual biology: 'apomixis', which is also known as asexual seed formation.

Asexuality

There are many non-agronomic plants that can reproduce asexually, meaning they bypass the need for meiosis during gamete formation and fertilisation by male sex cells to form a seed. Sorghum and cowpea are not among them.

"If a hybrid seed is equipped with genetic switches to make female sex cells by mitosis and also produce embryos without fertilisation, the hybrid would be self-seeding, and able to make clones of itself via seed," Professor Koltunow says.

"We are developing prototypes of such plants and testing if this will lock in those valuable hybrid characteristics when the hybrid seed was planted, flowered and produced more seed.

"In developing countries, this would allow hybrid seed to be retained and re-sown on-farm for multiple generations, with the farmer able to realise yield gains, and pocket the income otherwise required to purchase hybrid seed each year.

"In developed countries, the technology will reduce seed costs and increase the rate of genetic improvement."

Professor Koltunow says the strategy was looking very promising for sorghum but there was much work to do.

Cowpea, like most legumes, is not normally cultivated as a hybrid. A suite of tools is required to enable the genes to switch on in the right place at the right time. The Hy-Gain research collaboration is expanding knowledge of cowpea genomics (analyses of cowpea genetic materials), transcriptomics (to analyse changes in gene expression) and using state-of-the-art transformation techniques (to specifically alter cowpea genes) to support the project goals.

Messing with sex

One of the most striking aspects of the advances made in the prior research phase under Professor Koltunow's leadership is the relatively small number of changes required to switch to an asexual mode of seed formation.

The changes prevent the female sex cell from undergoing a special kind of cell division (meiosis) that would normally halve the number of chromosomes passed onto the offspring and also diversify the genetic content of those chromosomes.

By keeping a full complement of (unshuffled) chromosomes, the female sex cell is competent to form the embryo of the seed, without fertilisation, through the action of another gene.

"The ultimate goal of our work, in the long term, is to deliver African-adapted sorghum and cowpea varieties with improved yield and resilience traits," she says.

"In order to do that, we need to ensure that we develop a technology that can be readily used in breeding. We need flexibility to switch between sexual and asexual seed formation. This would enable us to rapidly develop new hybrid varieties, targeted to specific agro-ecological regions, and support improvement of non-hybrid varieties with resilience and quality traits to get them to the grower faster, avoiding varietal stagnation.

"We are already factoring these considerations into the next phase of the project, if Hy-Gain is as successful as we hope".

If developed as a practical breeding tool, this technology has numerous other applications, including within Australia's sorghum breeding program, and also in adapting the grains industry to climate impacts that are confronting the nation with hotter and drier growing conditions.

Professor Ian Godwin with GMO sorghum. Photo: Carolyn Martin © UQ

Breakthrough in boosting sorghum protein content

Researchers at QAAFI have achieved a major breakthrough in sorghum, using CRISPR gene editing technology to elevate the protein of the globally important cereal crop from 9–10 per cent to 15–16 per cent.

Sorghum is an important crop worldwide for human diets, in the production of alcoholic beverages and as animal fodder.

Led by QAAFI's Centre for Crop Science Director Professor Ian Godwin, the gene editing breakthrough in boosting sorghum protein content has the poultry and pig industries particularly excited, as well as beef feedlots.

For example, the increased protein is expected to deliver a 50-cent per head reduction in the cost of producing a two-kilogram meat bird.

The breakthrough is also expected to generate big interest in the 46 sub-Saharan African countries, where an estimated 500 million people rely on sorghum as a food source.

Professor Godwin says the genes of the sorghum plant had been edited to unlock the digestibility level of the available protein.

"Gene editing has enabled us to knock out some of the existing genes," Professor Godwin says

"That has increased the digestibility of the crop."

The new, high-yielding gene-edited sorghum is being developed in partnership with Pacific Seeds, with further development work expected to be carried out in the United States.

Professor Godwin - who has more than 20 years' experience in plant biotechnology research – is well known as the author of *Good Enough to Eat?*, a book about new genetic plant and animal breeding technologies.

Good Enough to Eat? charts the history of genetically modified foods from the laboratory to the global dinner plate, and outlines the huge potential of new gene editing technologies, such as CRISPR.

CRISPR technology is a precise tool for editing genomes. It allows researchers to alter DNA sequences and modify gene function, which can be used to improve crops. The technology was adapted from the natural defence mechanisms of bacteria and archaea, and its use in agriculture in Australia was recently deregulated.

Professor Godwin says he hoped the book was helping to end fear and misinformation generated by "fake news" about the safety of genetically modified foods.

"If we are to produce more sustainable and nutritious food to meet the growing global demand – in the face of challenges from pests and diseases, eroded soils, lack of water and climate change – we need to be able to take the best from the latest genetic technologies and from organic and agro-ecological farming practices," he says.

Professor Godwin began working on plant genetic engineering at Birmingham University in the UK in the 1980s. Since 1990, he has held an academic position in plant molecular genetics at The University of Queensland.

Professor Godwin is also passionate about the public communication of science, including genetics, GM plants and food, animal cloning, and the future of agriculture in a changing climate.

Associate Professor Bhagirath Chauhan.
Photo: Carolyn Martin © UQ

Controlling glyphosate-resistant weeds

The emergence of herbicide-resistant weeds poses a threat to the water-use efficiency of Australian cropping systems. However, effective control of glyphosate-resistant weeds is proving possible using a mix of existing herbicides, with the new application protocols developed by a five-year national Grains Research and Development Corporation (GRDC) research initiative.

Launched in 2015, the project is led by weed control expert, QAAFI's Associate Professor Bhagirath Chauhan, who works in collaboration with the NSW Department of Primary Industries (NSW DPI).

Associate Professor Chauhan says the overarching goal was to avoid a situation where the soil health and water conservation benefits associated with no-till are threatened by the need to use tillage to control glyphosate-resistant weeds.

"No-till farming was developed around the use of glyphosate to control weeds," he says.

"Since 1996, however, we have witnessed many of those weeds that are most problematic to agriculture develop resistance to this herbicide and to do so with increasing frequency.

"Finding effective and sustainable control measures for glyphosate-resistant weeds is an issue of national importance."

Targeted by the project are new herbicide treatments for the site-specific management of feathertop Rhodes grass, awnless barnyard grass, fleabane, common sowthistle, brome grass, barley grass and wild radish present in crop and fallow situations.

New protocol

The most advanced of the new weed control protocols are those for use in the northern growing region to control weeds during the summer fallow.

The method involves rotating a Group A, C and H herbicide in a three-year cycle. However, to achieve full control of the resistant weeds, it was found necessary to add in a Group L herbicide (typically paraquat).

This can be achieved either by mixing the Group C or H herbicide with paraquat in the spray tank, or spraying sequentially in a double-knock.

When applying a Group A herbicide, however, it should not be mixed in the tank with paraquat but rather applied in a double-knock only.

Application rates were based on the manufacturer's recommendations, with the inclusion of different chemical groups in a rotation regime designed to ease selection pressure on weeds to evolve resistance.

The approach is proving successful against glyphosate-resistant awnless barnyard grass and feathertop Rhodes grass – the weeds posing the greatest threat to the northern cropping region.

Ongoing work is now validating the glasshouse findings in field trials.

Weeds most problematic in the southern and western growing regions are concurrently under investigation with collaborators at The University of Western Australia and the University of Adelaide.

The focus in the southern region is on alternative options for controlling winter grass weeds.

In the western region, work will finalise new treatments to combat wild radish.

Timing

Additional research undertaken by Associate Professor Chauhan has further demonstrated that herbicide efficacy can vary, depending on conditions in the paddock and level of moisture in the soil.

This work was based on analysing glyphosate treatment of windmill grass (*Chloris truncata*).

In discoveries published in *Nature Scientific Reports* in July, Associate Professor Chauhan found that the efficacy of glyphosate decreases when weeds are moisture stressed in both herbicide-susceptible and herbicide-resistant biotypes.

In turn, the reduced efficacy can result in sub-lethal doses of glyphosate that promote weeds developing resistance, thereby exacerbating weed control challenges.

"We are already seeing field conditions severe enough to reduce glyphosate's efficacy," he says.

"That means it is becoming increasingly important that moisture stress, as it affects plant health, is considered when making decisions about applying herbicides."

Work is now underway at QAAFI to fully characterise the relationship between moisture stress and herbicide efficacy in fine detail.

The goal is to derive surrogate measures based on soil moisture content and the growth rates of weeds to help growers adjust the timing of herbicide applications to optimise efficacy and minimise the risk of developing resistant weeds.

SOURCE: Original article by Dr Gio Braidotti 'Existing herbicides deployed to tackle glyphosate-resistant weeds' was published in *Groundcover* on 30 December 2019.

Dr Jack Christopher © UQ

Genetic remix may deliver new all-climate wheat

Dr Jack Christopher and his team at the Leslie Research Facility in Toowoomba are breeding greater drought resilience into Australia's wheat crops.

A plant's genetics can affect its susceptibility to environmental stresses, including to drought, which is becoming a major drag on the world's food production systems, limiting yield increases and bringing food insecurity ever closer to a critical tipping point.

Breeding for improved yield in dry seasons, however, can lead to something of a paradox: individual genes that improve resilience may also cause yield penalties in good years. These good seasons are when bumper harvests provide the income allowing farm businesses to bridge the increasingly frequent tough years.

Modelling of historical climate data indicates that good years for wheat yields make up just 12 per cent of seasons in Australia's northern grains region. This creates considerable pressure to earn more in the majority of seasons when crops are water-stressed late in the season, as has occurred in several recent seasons.

However, QAAFI researchers have made a significant breakthrough in defeating the drought tolerance paradox.

Dr Jack Christopher and his team have developed a technique that better accommodates the genetic complexity needed to breed in wheat resilience to dry conditions, particularly to water stress around flowering, without compromising production in good seasons.

Their approach involves starting with three elite wheat varieties that are popular for their high yield potential in the western, southern and northern grain regions – Mace (PBR), Scout (PBR) and Suntop (PBR), respectively.

They then developed a technique to introduce many subtle genetic differences across the genomes of these elite varieties.

It is this genetic diversity across the network of genes that boosts yield resilience in dry years, but with careful selection can avoid introducing gene combinations that reduce yields in the all-important good years.

Dr Christopher says the best of the improved breeding lines has consistently exhibited high yield in trials at 21 sites across Australia. Some lines had a greater than 85 per cent chance of out-yielding the three elite parent varieties in dry years.

He says that extensive field tests indicate that the enhanced lines can reliably lift crop performance in the dry seasons. Prompt uptake by commercial breeders has meant that advanced new wheat varieties with this capability could start reaching growers within a few years.

A genetic basis for greater resilience

Anchoring the innovation achieved by Dr Christopher's team were prior studies of wheat lines that yielded 10 to 20 per cent more than standard lines under water-stressed conditions in the northern growing region, at many sites and over many seasons.

The improved yields were associated with two overarching plant characteristics that are based on complex genetics.

The first characteristic is a delay in leaves turning brown and dying (senescing) at the end of a season. This delay allows crops to better complete the process of setting seed and filling grain under dry conditions.

"This delayed senescence is called stay-green. One trait underpinning stay-green in wheat is a delay between flowering and the commencement of leaf browning," Dr Christopher says. "Field trials indicate that one to two per cent more yield is possible for every day that leaves delay the onset of the browning process, which can add up to 10 per cent higher harvests."

The second overarching characteristic relates to the architecture of the root systems.

"An advantage in yield and yield stability was observed for plants with root systems that have a narrower overall spread, with less roots to the side, but a greater proportion of the roots directly underneath the plant," Dr Christopher says.

"These roots were growing deep into the soil where they can tap into reserves of moisture late in the season."

The underlying genetics, however, have made the traits too complex for routine use by commercial wheat breeders.

Breakthrough breeding

To get around this problem, Dr Christopher's team crossed the elite varieties that are favoured by growers with up to 12 additional parents that served as donors of the stay-green and narrower root spread.

This produced genetically related lines collectively called a 'multiple reference parent (MR) nested association mapping' (NAM) population.

Facilitating this intensive pre-breeding work was the speed breeding technique, which allowed the development of the MR-NAM population in just 18 months, producing over 1500 inbred lines. Conventional crossing allowing only one new generation a year could have taken decades.

Extensive field testing was then used to rate the population's performance under real-world growing conditions. Lines were also examined for their stay-green in the field while root spread was tested in the laboratory.

Some of the best performing MR-NAM lines were passed on to commercial breeding companies in 2017 and have now progressed to advanced variety trials in at least one commercial breeding program.

To further boost performance, Dr Christopher's team crossed some of the best-performing MR-NAM lines together to combine even more root and stay-green genetics into the elite varieties.

This more advanced germplasm was made available to breeders for the first time in 2019.

Moving forward, the MR-NAM population now provides a gateway for the rapid transfer of additional traits into this elite material or into newer elite backgrounds.

Already, QAAFI researchers are setting their sights on donors that can provide enhanced heat tolerance and additional water-use efficiency traits based on transpiration biology.

This project is funded by The University of Queensland, the Department of Agriculture and Fisheries Queensland, and the Grain Research and Development Corporation

Based on an article by Dr Gio Braidotti in GRDC's Groundcover, *published 23 March 2020.*

Computer simulations boost efforts to manage wheat quality risks

Hotspot areas in Australia's wheatbelt have been identified that are especially prone to a climate-induced grain quality defect.

Dr Andries Potgieter

Australia's $5.8 billion wheat industry earns its market share by producing high-quality milling grain.

That standard, however, is at risk whenever weather conditions interact with genetics to produce a grain-quality defect called late-maturity alpha-amylase (LMA).

In LMA-affected wheat varieties, a starch-digesting enzyme (alpha-amylase) is prematurely activated. This causes otherwise normal-looking grain to fall below internationally accepted grain trade quality specifications.

Currently, growers are protected from LMA through the Wheat Quality Australia Classification process for milling-grade wheats. This classification means that LMA-susceptible lines can't be released as milling wheat varieties in Australia.

Without the classification process, growers could potentially face a $20 to $50-per-tonne penalty when LMA-affected grain is segregated into the general purpose or feed grades, instead of the more lucrative Australian Prime White (APW) grade.

"Without classification, the impact of LMA could be especially detrimental to the Australian grains industry because Australia exports a high proportion of its wheat into quality-sensitive markets in Asia," says QAAFI's Dr Andries Potgieter, an expert in complex integration of remote sensing technologies, spatial production modelling, and climate forecasting systems at a regional scale.

However, the current lack of detailed knowledge around the genetic basis and environmental triggers for LMA make it difficult to select against in wheat breeding programs. This means that some high-yielding elite breeding lines are lost in the classification process.

Dr Potgieter and his team have been working to help the industry understand LMA by learning to predict both the genetic and environmental factors that pose the greatest risk.

Most recently, the QAAFI team developed diagnostic computer simulations to map the LMA risk posed by one well-characterised environmental trigger.

The trigger involves wheat plants experiencing a cold shock about 26 days after flowering during the mid-grain-filling stage of development.

Knowing this, the researchers searched enormous datasets – derived from high-quality climate stations across the Australian wheatbelt – for such trigger events.

"Our predictive framework fed the weather data into a biophysical crop model to simulate plant growth and detect weather events likely to trigger LMA during the susceptible grain development window," Dr Potgieter says.

The model produces maps that depict the level of LMA risk to wheat crops at the shire scale.

The maps show higher levels of risk in clusters along a narrow band of shires across the southern region of Australia. The remainder of the southern region shows more moderate risk levels in bands.

These are more extensive in South Australia and less so in Western Australia and Victoria.

For Queensland and NSW, the risk was estimated to be quite low.

However, Dr Potgieter adds that the risk profile varies for different sowing dates and for wheat varieties with different maturity types.

"What we see is risk increasing with earlier sowing dates and with early-to-medium maturing varieties," he says. "That's because flowering and, more importantly, the grain-filling period, are more likely to coincide with cooler conditions."

The new tool is helping wheat-breeding companies to better understand the LMA hotspots. Options to manage potential future risk include exploiting genetics better suited to later sowing dates.

The simulations from the completed project draw on seasonal climate conditions at the shire scale around the country. A new initiative in 2020 will drill down further to better understand risks at the paddock scale.

First late-maturity alpha-amylase (LMA) research meeting held in January 2020. Pictured (L-R): Jeremy Curry (DPIRD WA), Haydn Kuchel (AGT), Genevieve Clarke (BCG), Kenton Porker (SARDI), Daniel Mullen (IG), Felicity Harris (NSW DPI), Bertus Jacobs (LRPB), Robert Armstrong (UQ), Jason Brider (QDAF), Andries Potgieter (UQ), Kelly Angel (BCG), Miranda Mortlock (UQ & QUT). Project team members not in photo: Graeme Hammer (UQ), Ben Biddulph (DPIRD WA), and Brian Cullis (BBAGI).

"The risk of LMA incidence at field scale, across Australia's wheatbelt, is currently not well understood," Dr Potgieter says.

"To close that knowledge gap, the Grains Research and Development Corporation is co-investing with other research partners to develop a predictive model for LMA incidence at field scale for a range of LMA-susceptible genotypes."

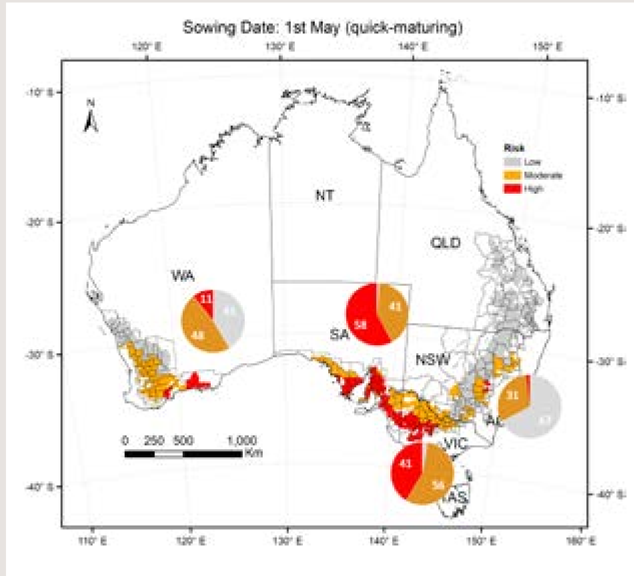
The new initiative is also an opportunity to deepen the understanding of LMA trigger events by delving deeper into the way genes and environment interact to damage grain quality.

"We know that out in the field, temperature is not the only trigger controlling LMA," Dr Potgieter says. "This new project will allow us to get down to the field scale, and expand our knowledge of the LMA triggers."

Outputs from this next phase are expected to create unprecedented opportunities for wheat breeders to better understand both the genetic and environmental factors at work in LMA.

The new three-year initiative includes a multidisciplinary team of scientists from The University of Queensland, Western Australia's Department of Primary Industries and Regional Development, NSW Department of Primary Industries, South Australian Research and Development Institute, and Birchip Cropping Group, as well as plant-breeding industry partners Australian Grain Technologies, InterGrain and LongReach Plant Breeders.

This project is a co-investment between the Grains Research and Development Corporation, University of Queensland, and the Department of Agriculture and Fisheries.



Putative-risk footprint maps for experiencing temperatures of the cool-shock regime in the field for a fixed sowing date on 1 May each year and a quick-maturing wheat variety simulated using daily weather data from 1901 to 2016. Pie charts indicate percentage of land-use area associated with the broad risk classes.

Modern wheat varieties prove hardier than expected

The myth that modern wheat varieties are more heavily reliant on pesticides and fertilisers than older varieties has been debunked by new research.

QAAFI's Dr Kai Voss-Fels says modern wheat varieties have out-performed older varieties in side-by-side field trials under both optimum and harsh growing conditions.

"There is a view that intensive selection and breeding, which has produced the high-yielding wheat cultivars used in modern cropping, has also made them less resilient and more dependent on chemicals to thrive," Dr Voss-Fels says.

"However, the data published today unequivocally shows that modern wheat out-performs older varieties, even under conditions of reduced amounts of fertilisers, fungicides and water.

"We also found that 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 researchers 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.

Overall, the newest cultivars performed significantly better than the oldest for almost all traits analysed, even in reduced input production systems.

In fact, the genetic gain of modern cultivars for sustainability-related traits, such as nitrogen-use efficiency or disease resistance, were even more apparent under reduced-input scenarios.

Even cultivars registered specifically for organic agriculture rarely outperformed conventionally bred cultivars from the same year of release.

"Quite a few people will be taken aback by just how tough modern wheat varieties proved to be," Dr Voss-Fels says.

"Even their ability to adapt to harsh growing conditions, such as drought, is superior."

Efforts are now underway in Australia to realise these additional yield gains using exceptionally efficient and rapid breeding technologies available at The University of Queensland.

Dr Voss-Fels and Professor Ben Hayes, Director of QAAFI's Centre for Animal Science, have developed a method to match the performance differences with the different varieties' genetic make-up.

"This genetic information allows us to take the discovery to the next level," Dr Voss-Fels says.

"We want to develop breeding strategies to bring together favourable alleles in new cultivars in the shortest possible time."

"We are using artificial intelligence (AI) algorithms to predict the optimal crosses needed to bring together the most favourable segments as fast as possible."

Global yields of the world's most important food crop have been reduced by droughts in recent years.

Dr Voss-Fels says with more climate risk anticipated, the hardiness of modern wheat varieties was an issue of global significance.

"Increased breeding efforts are needed to enhance the resilience of wheat varieties to challenging environmental conditions."

Dr Voss-Fels says the study's findings could also have important implications for raising the productivity of organic cropping systems.

Professor Rod Snowdon of the Justus-Liebig-University Gießen (JLU) and collaborators from seven other German universities led the research.

The study was published in *Nature Plants* on 17 June 2019.

Dr Voss-Fels says the findings might surprise some farmers and environmentalists. Photo: Kai Voss-Fels

Pigeonpea © Shutterstock

Pigeonpea takes flight

Pigeonpea is making its way onto Australian farms as more severe drought causes a rethink of the crops best suited for cultivation in the northern growing region.

The advent of more frequent and severe droughts has hit a critical juncture for agriculture – the point where farmers need to swap out standard staple crops because they are insufficiently drought resilient.

Already in parts of India, popular maize crops have been replaced by drought-tolerant sorghum.

A similar adaptation strategy is now underway to help farmers in Queensland and northern New South Wales deal with shortfalls in summer rainfall needed to successfully cultivate mungbeans, soybeans or peanut.

The solution? Introduce the drought-hardy legume, pigeonpea (*Cajanus cajan*), a protein-rich crop that is vital to the survival of resource-poor farmers in the semi-arid tropics of Asia and Africa.

This strategy retains the soil benefits obtained from the inclusion of a legume in a farm's crop rotation. Concurrently, farmers benefit from a much-needed boost in the cropping options available to them, especially for more marginal seasons.

This timely innovation is the work of Associate Professor RCN Rachaputi, a legume crop physiologist based at QAAFI's Gatton campus.

In 2019, Associate Professor Rachaputi launched a pigeonpea-breeding program that aims to produce a high-yielding variety adapted to Australian growing conditions within about four years.

This work is funded exclusively by an industry partner capable of processing and marketing Australian-grown pigeonpea – an essential prerequisite for growers to adopt the new crop.

"We performed a feasibility study leading up to this project that found pigeonpea – with its high levels of drought and heat tolerance – is a viable option for the northern grain-growing region," Associate Professor Rachaputi says.

"We found that pigeonpea outperforms mungbeans no matter the environment, a finding that has created a lot of industry interest, including requests for seed from growers."

Yields possible on Australian farms are likely to be among the best in the world, with four tonnes of pigeonpea per hectare achieved in Queensland under non-limited conditions and at optimal row-spacings.

This compares favourably with the two tonnes per hectare achieved by growth in research plots in the world.

In India, where the crop was originally domesticated more than 3500 years ago, current average yields of pigeonpea are just 0.9 tonnes per hectare, reflecting heavy losses due to a single pest – *Helicoverpa* pod borer, a moth that can also devastate cotton crops.

Associate Professor RCN Rachaputi and Mr Solomon Seyoum. Photo: Carolyn Martin © UQ.

Anticipating the adverse impacts of this pest to Australian growers, Professor Rachaputi is taking an ingenious approach to provide Australian varieties with in-built genetic resistance.

His approach involves screening Australian native species that are wild relatives to cultivated pigeonpea for the needed pest resistance genes.

"Wild pigeonpea proliferates across the northern section of Australia making this region one of three globally significant centres for pigeonpea biodiversity," Associate Professor Rachaputi says.

"My team has been characterising this biodiversity and we have identified species that are 100 per cent resistant to *Helicoverpa*.

"Now my challenge is to work up a way to transfer those wild genes into the cultivated lines."

The breeding program is also selecting for important productivity characteristics, especially:

- reducing the height of pigeonpea from about three metres to a machine-harvestable 0.5 metres;
- increasing seed size by 30 per cent and changing seed colour to white or red
- earlier maturity by developing varieties that are sensitive to changes in day length.

Associate Professor Rachaputi is using the most advanced breeding technology available anywhere in the world, including Gatton's new speed breeding facility, which makes it possible to grow four generations of pigeonpea in one year.

Additional acceleration is possible by the development of algorithms that can simulate impacts of pigeonpea biodiversity on growth rates, flowering time, yield, and impact on yields of Australian growing conditions.

"This means we can accelerate the delivery of a much-needed new option for our cropping systems that are in real need for another broadleaf legume. From what I have seen to date, I think the new pigeonpea variety under development will fill that role."

HORTICULTURAL SCIENCE

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

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Research themes:

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› Plant protection
› Emerging technologies

Macadamia. Photo: Shutterstock

Disease management lifts macadamia industry confidence

Australia's native macadamia nuts are worth over $250 million in exports a year, and research to improve disease management is helping to step up the crop's productivity to further increase its value.

Assoc Prof Femi Akinsanmi

Macadamia nuts are already the nation's fourth-largest horticultural export. But despite the plant's evolution in Australia over some 60 million years, it remains susceptible to both endemic and exotic disease pathogens that challenge commercial production.

To support industry development, QAAFI has been investigating a range of native, emerging and exotic diseases and developing integrated approaches to reduce disease impacts.

Australian Macadamia Society CEO Jolyon Burnett says research from QAAFI has given growers the knowledge and confidence to apply flexible and holistic farm management practices, and to respond to issues as needed rather than following a set 'recipe' approach.

Plant pathologist Associate Professor Femi Akinsanmi has led the research for over 10 years and has played a vital role in the ongoing success of Australia's macadamia industry. Innovation has been a key feature of his approach – for instance, successfully using a mechanical tree shaker to prevent husk spot disease without the need for fungicides.

Husk spot is caused by the pathogen *Pseudocercospora macadamiae*; it leads to a significant premature nut drop and production losses that have been estimated at $10 million a year.

Researching the disease's biology and epidemiology, Dr Akinsanmi found that the fungus spreads from old tree husks – the fibrous protector around the macadamia nut's shell – to new green ones. The pathogen inoculum can persist in old husks for more than two years.

Some divergent thinking led him to a novel management tool – a mechanical tree shaker, which helps to remove all husks from trees, thereby removing sources of potential infection. It has proven so successful it has eliminated the need for fungicide sprays to treat the disease in trials.

"Shaken trees do not carry any husk-spot inoculum into the next season," he says. "The tree shaker also improves harvesting efficiency by shortening the harvest period."

Research has addressed the serious soil-borne pathogen *Phytophthora cinnamomi*, resulting in tree decline and death. Lost macadamia productivity resulting from this pathogen has been estimated at $20 million a year.

Efforts to understand the pathogen, the ability of trees to resist the disease and the related soil health issues have led to a range of control strategies growers can use to quickly identify and respond to the disease.

These include assessing the health of trees for signs of infection, selecting tolerant rootstock, and ensuring good drainage and orchard hygiene, along with chemical controls when needed.

The development of a targeted chemical delivery method to treat *Phytophthora cinnamomi* has reduced spray applications and has been recognised and adopted nationally and internationally to manage similar diseases in other tree nuts.

Mr Burnett says the QAAFI research has helped macadamia growers move from simply coping with the disease and decline in tree health to actively managing it, which has led to improved farm and industry productivity.

Growers have moved from practices such as calendar spraying, with up to five applications of chemical treatments a season, to a watch-and-respond approach.

"What Femi has done has made us all better farm managers across the board, not just in relation to our broader industry-funded project on Integrated Pest and Disease Management. It is a critical shift that has saved money and improved sustainability and responsible practices in the communities we operate in," Mr Burnett says.

Future

From his base at The University of Queensland, Dr Akinsanmi's research and extension continues, with Flower Blight as the latest emerging challenge for the industry in Australia.

It is caused by two novel pathogen fungal species and leads to complete crop failure. Already ahead of the game, Dr Akinsanmi has pioneered the detection and diagnosis of these fungal species. Now he and a team of PhD students are working to understand its biology so control measures can be developed.

Globally, Dr Akinsanmi also leads the international research and development program on macadamia diseases for the International Macadamia Symposium Committee – a role that helps him remain vigilant to any emerging exotic threats to the industry, as well as local ones.

This research has been funded by Hort Innovation, using the macadamia research and development levy and contributions from the Australian Government. Macadamia research at QAAFI is supported by the Department of Agriculture and Fisheries.

Next-generation macadamias

Until recently, the Australian macadamia industry had been based on varieties little improved from the wild macadamias that are native to southern Queensland and northern New South Wales.

Professor Bruce Topp

But in 2017, four new cultivars were released by the Department of Agriculture and Fisheries (DAF) and Horticulture Innovation Australia (HIA) as part of a long-running breeding effort run by QAAFI.

The new cultivars have their origins in a 1996 CSIRO initiative, and follow 22 years of selection trials.

The Macadamia Breeding and Conservation project was led by QAAFI's Professor Bruce Topp, in the Centre for Horticultural Science.

In 2019, HIA established the next five-year phase of the program – the $2.3 million National Macadamia Breeding and Evaluation Program, led by Professor Topp.

"We're concentrating on producing a much larger number of seedlings, and we've developed a new method to screen them much more rapidly," he says.

"Our vision is to have the Australian-bred cultivars as the nut of choice."

Professor Topp says "the project will be focused on selecting for the industry-defined target traits of yield, tree size, nut quality, rootstocks and pest resistance."

"We'll be doing this by using modern quantitative genetic analysis and incorporating genomic technologies," he says.

"We will be moving into second and third generation of breeding by further developing some of the second-generation macadamia populations developed in our last project."

Dr Alice Hayward. Photo © UQ

Researchers dish up digital avocado

It's an ancient fruit, but the avocado has been brought into the new millennium with the publication of its draft genome, which may be the key to improvements in future crops.

Professor Neena Mitter. Photo: © Lyndon Mechielsen, The Australian

Professor Neena Mitter, Director of QAAFI's Centre for Horticultural Science, along with colleagues Dr Alice Hayward and Stephen Fletcher, collaborated on the international research led by Professor Luis Herrera-Estrella that recently published the first draft sequencing of the Hass variety genome.

Professor Mitter says the avocado had around 25,000 protein-coding genes – roughly the same as humans.

"There is a lot of genetic variation in avocado, and this new genetic information, coupled with advances in big data means there's huge potential for future crop improvement and breeding that we can now tap into," Professor Mitter says.

"Unlocking the avocado genome will help us better target management practices by understanding the genetic controls for biological processes that influence commercially important traits."

UQ researchers in the Hort Innovation National Tree Genomics Program will now complete the final assembly of the genome.

Hort Innovation's R&D Manager Dr Vino Rajandran says having a detailed blueprint of the avocado genome would provide the Australian industry with an important tool to drive future productivity.

"It will give us new insights into improved tree architecture and flowering, and the intensification of orchards, which are priorities of our National Tree Genomics Program," Dr Rajandran says.

Avocado can be traced back 65 million years to the beginning of the Cenozoic era, and was a source of food for giant sloths and other large animals.

Dr Hayward says the genome draft also helped unravel how the fruit evolved.

"Avocado is an ancient flowering tree in the family that also includes cinnamon," Dr Hayward says.

"The genome data supports the idea that the avocado lineage split from other flowering plants around 150 million years ago."

As well as being valued for its buttery flavour and health qualities, avocado is an important crop of Mexico, which produces about half the world's supply.

The UQ team also provided sequence data for Velvick, a disease-tolerant rootstock that is widely sought after in Australia for grafting new avocado trees.

"Avocados can be highly susceptible to diseases such as phytophthora root rot, so having this new understanding of avocado genetics will be important in combatting the disease, and also disease like black spot," Professor Mitter says.

Avocado is an economically important fruit crop, with the global market predicted to reach US$23 billion by 2027.

The Australian component of this work was supported by Hort Innovation through a Science and Innovation Award and Minister's Award from ABARES (Australian Government Department of Agriculture).

Avocado propagation research trial targets high yields

Avocado farmers could start producing more fruit to keep up with demand once world-first propagation technology, trialled in the Bundaberg region, is commercialised.

It's a world-first for the industry, with the success of the technology never having worked before due to the "traditionally finicky nature" of avocado trees.

Director of Horticultural Science at The University of Queensland, Professor Neena Mitter, and her team at QAAFI have been working on avocado tissue culture propagation as part of a joint Queensland Government and industry-funded project.

Professor Mitter says the technique, which was currently on trial at a number of sites including Donovan Family Farms in Childers, increased the number of avocado trees that could be propagated from one single shoot.

"Rather than the normal propagation technique of creating one plant from one cutting or one plant from one seed, this new technology allows 500 clonal plants from a single shoot-tip in culture within 8 to 12 months," she says.

"The end goal is to create a tool that allows farmers to have the rootstock variety they want, in the numbers they want, when they want it."

Working with industry to trial seedling propagation

Donovan Family Investments in Childers has been involved in the research project for almost three years, with Director Lachlan Donovan saying a number of propagated avocado trees had been growing at the farm for the past 18 months.

"It's certainly been successful so far," Mr Donovan says.

"The trees are all growing. We are still a little way away from setting commercial crops but the theory all works and we have trees in the ground."

Mr Donovan says the technology would work to reduce both the cost and the timeframe from ordering trees to planting.

"This has in the past been a delay of two to three years," he says.

"The biggest advantage for us is to be able to get overseas rootstocks and varieties quickly into production.

"Traditionally, if a new variety came out overseas, it would be around 10 years or longer to get the trees imported, several years in quarantine and then grown out here to get budwood to start the commercialisation."

Mr Donovan says with the new technology, his farm could bring in tissue culture material to propagate and multiply so commercial plantings of new varieties would be available in as little as 18 months.

"This would work for both the rootstocks and variety," he says.

"It would be fantastic to be able to have the latest varieties ready for the consumer as quickly as possible."

Export benefits

Dr Madeleine Gleeson, who manages the field trials of this project, says the research could benefit farmers Australia-wide, providing a productive, competitive and sustainable avocado industry for years to come.

Dr Madeleine Gleeson © UQ

"Currently, fields must be maintained just for seed (not fruit) to produce new trees," she says.

"This costs water, fertilisers, pest management, and so forth, and is consuming valuable arable land for non-food production purposes.

"Tissue culture can make hundreds of new trees from a few shoot tips in a small sterile room and is therefore significantly less resource intensive."

Dr Gleeson says there were also benefits when it came to the export of the seedlings.

"The material is sterilised from all bacteria and fungus, so the risk of spreading pathogens around the globe is significantly reduced," she says.

"Furthermore, they would be transported on a sterile agar that contains all the nutrition the plants need; movement of soil is a massive biosecurity risk and is thus eliminated with tissue culture."

Dr Gleeson says with funding from an Advance Queensland Innovation Partnership and in partnership with the University of Southern Queensland and Central Queensland University, the researchers would continue to monitor the project, with the potential for the technology to reach further than just avocado farms.

"Tissue culture is already used to propagate many different berry species, apple, kiwi fruit, banana and more," she says.

"It is a propagation tool that has existed for years. It has just never been successful for avocado as the woody tree species are traditionally finicky to work with.

Original article by Ashley Clarke published via 'Bundaberg Now' on 10 February 2020.

Associate Professor John Thomas and colleagues from UPLB, collecting wild banana germplasm on the island of Mindoro, Philippines. © John Thomas

Preventing a viral banana pandemic

The devastating Banana Bunchy Top Virus nearly wiped out Queensland's banana industry over 100 years ago. But an international team of researchers, aided by funding from the Bill & Melinda Gates Foundation and led by QAAFI's Associate Professor John Thomas, have developed promising strategies to protect this key food source for communities in sub-Saharan Africa and prevent further spread of the disease.

It's not just humans that benefit from 'flattening the curve' of virus transmission during a pandemic. The same premise is at work defending global food security from viruses that can decimate agricultural production systems.

Agricultural pandemics are especially alarming when they affect staples that provide the base to diets around the world. Among the 10 top staples – which includes bread, wheat and rice – are bananas, albeit in the form of 'plantain' or cooking varieties.

While recent attention has focused on the Fusarium Tropical Race 4 fungus that causes Banana Panama Disease, Queensland scientists are tackling another potentially equally devastating banana disease – Banana Bunchy Top Virus (BBTV).

"Bunchy top almost wiped out Queensland's banana industry more than 100 years ago," says QAAFI's Associate Professor John Thomas, who coordinates the international project and its participating 15 research institutes.

Banana bunchy was first identified in Fiji in 1889 and has spread around the world in infected plant material.

"The virus is controllable and with considerable effort you can get rid of it in a defined area, but history shows us that once the disease is established in one place it usually stays there, so our aim with this project was to get on top of this disease once and for all."

Banana Bunchy has been effectively controlled for Australia's $600 million banana industry based on advanced R&D efforts. In 2016, this expertise was tapped into by the Bill & Melinda Gates Foundation to help protect banana plantations among subsistence farmers in sub-Saharan Africa.

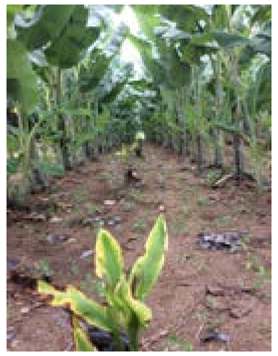
BBTV is transmitted to banana plants by aphids. The infection is devastating for farmers as it prevents banana bunches from forming for the life of a tree without killing that tree. The virus can also infect nurseries that produce planting material.

"Despite upward of 1000 different banana cultivars grown around the world, not one has proven resistant to BBTV," Dr Thomas says.

"This is especially concerning given that 85 per cent of bananas produced globally are consumed locally. The volume of food at risk from BBTV is staggering when you consider that the remaining 15 per cent of banana production makes up the largest volume of any fruit traded globally."

The approach being taken to defend plantations of impacted villagers is multi-pronged. It encompasses virus diagnostic tools,

Farmer in Benin showing his macro-propagated banana planting material. © John Thomas



BBTV-infected cv Lakatan with severe symptoms growing between BBTV-resistant Musa balbisiana *at a field screening site, UPLB, Philippines. © John Thomas*

monitoring, the removal of infected plantations, the capacity to produce clean planting material and a promising quest to source banana genes that offer resistance to BBTV infection.

On all fronts, impressive gains have been made. In the process, three new disease control tools have been developed:

1. diagnostic antibodies for field epidemiological studies, including among subsistence farmers in Africa and Asia;
2. modelling that can simulate years of field trials normally needed to identify optimal control strategies; and
3. the ability to identify BBTV resistance genes using a novel gene discovery strategy.

Test and detect

Dr Thomas says The University of Queensland leads the world in the development of diagnostic tools for BBTV. These are based on advanced virological studies. Included are cultured cells that produced the BBTV-specific antibodies used diagnostically around the world for the past 30 years.

Funding by the Bill & Melinda Gates Foundation permitted a fresh batch of this exhausted resource to be developed. DNA diagnostic capability was also developed with colleagues at the International Institute of Tropical Agriculture in Nigeria.

"When used in an ELISA assay, antibodies provide a robust and reliable test that can be performed even in poorly equipped laboratories," Dr Thomas says.

That resilience allowed surveys to be undertaken in sub-Saharan Africa and South East Asia. Widespread and growing infection rates were detected, especially in Africa. Impacts have been devastating, with infection rates of 50 to 90 per cent of trees detected.

"BBTV has been so destructive that villagers are transporting bananas to market on bicycles where once they would have used trucks," Dr Thomas says.

Pilot studies in Benin and Nigeria demonstrated that this devastation can be successfully reversed. These projects engage villagers in education programs that build the trust needed to attempt a radical strategy. This involves eradicating infected trees and replanting with material sourced from clean nurseries.

With these plantations rebounding within three years, the prosperity that comes with increased production is serving to demonstrate to many more villages the value of detecting and controlling BBTV.

Modelling

Key to rolling out disease-control strategies across so many different landscapes, climates and plantation practices are computer models developed in partnership with Cambridge University in the UK. These can simulate outcomes associated with different disease-control strategies without the need for years of costly field trials.

The modelling work draws on decades of data collected by Australian plantation inspectors who helped suppress BBTV spread in Australia since its introduction in 1916.

"We have used modelling in Australia for a number of years as part of a suite of tools that keep infected trees to below 0.1 per cent," Dr Thomas says.

"Modelling is now being adapted to African situations by adding relevant data."

A key question modelling is helping to answer involves the ideal location of nurseries that supply clean planting material to regenerate plantations. These need to be sufficiently apart from plantations to avoid infection but near enough to not impede adoption of clean nursery techniques.

Resistance

Where humans look to vaccines to stem a pandemic, agriculture looks to genes that endow plants with the ability to resist infection.

The quest for resistance genes in bananas, however, takes an intriguing turn given the fruit's heritage.

Dr Thomas explains that bananas as we know them do not occur in the wild. Like many staples, bananas are naturally occurring hybrids, the progeny of two different species.

Hybrids were selected for domestication by humans because they tend to be sterile, which results in seedless, edible pulp. As such, bananas are cultivated vegetatively through the propagation of suckers and more recently, through tissue culture.

However, none of the hybrids selected by humans for cultivation eons ago contain resistance to BBTV. In response, Dr Thomas shifted the search for resistance to the wild progenitor species.

This work involves several international collaborations.

Working with scientists in Belgium, genetic differences among wild species were mapped and categorised. This also involved learning how to propagate, store and work with banana seed.

A population representative of available diversity is now being challenged with BBTV in the Philippines using aphids to inoculate the plants.

Dr Thomas cautiously reports "promising results", but that means scientists are actually seeing banana plants that can outright resist BBTV infection.

Understanding the genetic source of that resistance would amount to a major breakthrough.

This project is funded by the Bill & Melinda Gates Foundation with further support from The University of Queensland and the Department of Agriculture and Fisheries, Queensland. The project will help protect Australia's banana industry from BBTV through improved diagnostic capabilities and building genetic resistance.

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

Nourishing Australia plan highlights need to track what foods Australians really are eating, as opposed to what they self-report they are eating. © Shutterstock.

Australian food scientists call for a nutrition revolution

Nutrition science offers huge untapped potential to boost the health and wealth of the nation.

Professor Mike Gidley

Leading Australian scientists have called for nutrition to be listed as a national science and research priority – and for the establishment of a 'trusted voice' to provide credible, independent evidence-based nutritional information.

Professor Mike Gidley, Director of QAAFI's Centre for Nutrition and Food Sciences, who chairs the National Committee for Nutrition established by the Australian Academy of Sciences, says nutrition was of critical importance to enable Australians to lead more productive lives.

"We are in the midst of a revolution in biology which is reshaping how we think about our bodies, health, the economy and the environment," Professor Gidley says.

"Our bodies contain more bacteria and other microbes than they do human cells, and the critical role these microbes play in regulating our physical and mental health is one example of how recent advances are transforming nutrition and health, as well as providing new opportunities for industry."

Professor Gidley says the ability to measure the trillions of microbes in our digestive tract – and how the gut microbiome interacts with food and our immune system – has been available only for the last five to 10 years.

"This presents a grand challenge for the nutrition sciences, which is to understand the body as a whole system and the real-time consequences of how we process and metabolise the food that we eat."

The Academy recently released *Nourishing Australia*, a decadal plan for nutrition science in Australia, proposing that nutrition be listed as a national research priority.

The plan also calls for increased national data capability on nutrition to provide robust evidence for policy-makers, more studies on cause-and-effect mechanisms underpinning diet-related diseases, and growth in the agri-food and 'nutritech' sectors.

"There are companies developing nutritech apps and tools that will measure dietary intake patterns and nutritional status in all sorts of new ways – comparable to the way fitness apps now measure steps walked, calories burned and sleep quality," Professor Gidley says.

"This will give us much more accurate information about what Australians are really eating because at the moment we have to rely on self-reporting and observational studies, which are not ideal."

"Australia is a very diverse country and we really need to fill the gaps in our knowledge about what people consume as part of their daily food and drink intake."

The establishment of a 'trusted voice' is another key plank of the plan, along with professional communications to counteract incorrect information posted on social media.

"One day we are told that a study says coffee is good for you, the next day we are told it's bad for you," Professor Gidley says.

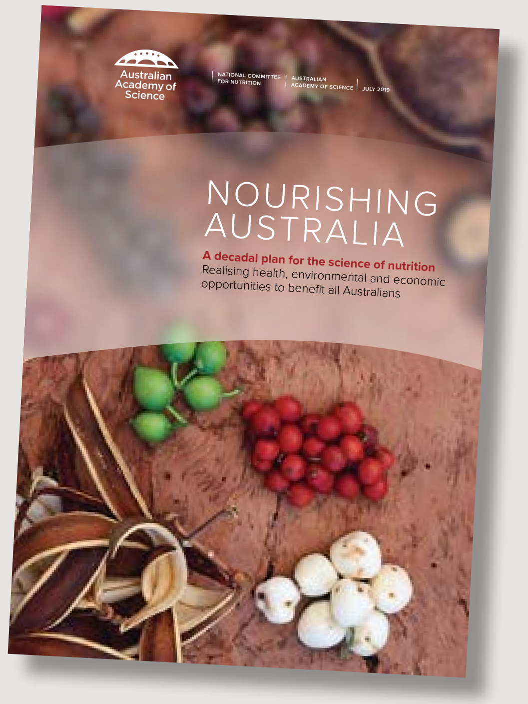
"There really needs to be a credible body that is not affiliated with commercial interests that Australians can trust for dietary advice, to counteract all the noise we hear on both social and traditional media."

Nourishing Australia: A decadal plan for the science of nutrition

This decadal plan sets out a strategy for realising the vision that Australian nutrition science plays a key role in improving long-term health and wellbeing globally, while delivering environmental, social and economic benefits nationally with core values of equity, sustainability, collaboration and innovation.

Successful implementation is expected to result in health, wellbeing and economic benefits, including:

- reduced burden of chronic diseases from increased nutrition literacy, and greater understanding of cause-and-effect mechanisms linking dietary patterns to health and disease
- cost-effective, equitable population health initiatives developed from accurate knowledge of current diet–health relationships and addressing societal and commercial factors
- improved diets leading to better physical and mental health
- nutrition credentials that will drive a premium agrifood sector, particularly for exports
- growth of a 'nutritech' sector that provides software, hardware, analysis and commercial services to support a healthy and sustainable food and health system
- helping to achieve global targets such as the UN Sustainable Development Goal.



Roast pork © Shutterstock

New research finds Australian pork flavour signature

Native macadamia nuts could prove the key to developing a distinctively Australian pork flavour profile as a premium product in both domestic and international markets.

Professor Eugeni Roura

Professor Eugeni Roura and his team at the Queensland Alliance for Agriculture and Food Innovation (QAAFI) have provided a proof of concept, creating a preferred flavour signature recognised by consumer sensory tests.

Professor Roura says the key to the flavour boost lies in an increased level of oleic acid in the fat composition of the meat, which is influenced by the inclusion of macadamia oil in the diet.

The initial concept for the Australian project was based on the internationally recognised and award-winning Spanish Iberico pork, which comes from the western territories of the Iberian Peninsula. Iberian pigs – a breed found only in this region – forage extensively on acorns, which are high in oleic acid. Earlier research at QAAFI had linked the highly regarded quality and taste of Iberico pork to higher levels of oleic acid in the intramuscular fat. The oleic acid is provided by the acorns.

"We don't have acorns in Australia, but we do have other potential sources of oleic acid such as macadamia nuts, which have a similar level of oleic acid," says Professor Roura, who is based at The University of Queensland.

Dr Marta Navarro, a Postdoctoral fellow at the QAAFI's Centre for Nutrition and Food Sciences, developed the feeding trial with Queensland producer SunPork. A selected group of animals were fed a typical global diet, including corn, soybean and corn oil. Other groups were fed diets with varying proportions of more distinctive Australian ingredients such as sorghum and lupins, as well as macadamia oil.

Professor Roura says carcase testing showed that the macadamia oil in the diet had increased the oleic oil levels – the monounsaturated fats – in the intramuscular and subcutaneous fat of the pork meat, reducing the proportion of polyunsaturated fats.

The monounsaturated-to-polyunsaturated fat ratio increased from as low as 0.4:1 in pork produced from a standard diet to as high as 3.2:1 from a modified diet. This, Professor Roura says, has proved to be the key contributor to an improved flavour profile in the meat.

In a preliminary test, QAAFI sensory scientist Dr Heather Smyth and her team of expert panellists defined the main descriptors that were used in the final consumer test.

In a final stage and under the guidance of Dr Navarro, the pork flavour was tested using a consumer panel with 80 participants, half of whom were long-time Australian residents, and the other half were of Chinese ethnic origin.

The roasted pork loins from pigs fed macadamia oil had higher caramelised notes and an overall improved pork flavour pleasantness particularly valued by the Chinese cohort of the consumer panel. Both groups reported more favourable responses to the high-oleic pork.

Professor Roura says that the research identifies an opportunity for Australian pork producers to develop a unique premium product that could potentially target both Chinese and domestic markets.

"We have successfully provided proof of concept for the creation of a distinctive Australian flavour through changes to animal diets," he says. However, additional research will need to assess alternative oleic acid-rich feed ingredients available to local producers aimed at minimising costs.

The research was funded by Australian Pork Limited and supported by The University of Queensland and the Queensland Department of Agriculture and Fisheries.

It is part of a larger body of work at QAAFI's Centre for Nutrition and Food Sciences, and its Uniquely Australian Foods initiative focused on identifying Australian provenance characteristics to help local producers create a range of value-added food products.

Purple power! Naturally nutritious sweet corn

Naturally Nutritious is a five-year cross-industry project developed by Hort Innovation to research the development of innovative food products and varieties, including sweet corn, strawberries and macadamia nuts, that are bred through traditional breeding practices to boost key nutrient levels, taste delicious, and are visually appealing.

One of the products being developed through the Naturally Nutritious project, led by QAAFI's Dr Tim O'Hare, in collaboration with the Department of Agriculture and Fisheries (DAF) Queensland, is purple sweet corn, with high levels of specific phytonutrients for human health.

Fruit, vegetables and nuts play an important role in human health, and Dr Tim O'Hare says that while most Australians are aware of the 'Go For 2 & 5' program and how many fruits and vegetables they should eat, most are not actually doing it.

"A major thrust of the Naturally Nutritious project was to investigate if we could increase the nutrient content of a range of products, so that you could get more bang for your buck, or 'more nutrition per serve'," Dr O'Hare says.

One of the considerations was the 'look' of the product that was being developed.

"For example, purple sweet corn, developed from Peruvian purple maize, clearly looks different to yellow sweet corn," Dr O'Hare says.

"Of course, the product has to taste as good – if not better – than the standard product, because after all, this is food and it should taste great. If it doesn't taste great, then the likelihood of you buying it a second time drops dramatically."

In some products, the pigment is actually the active nutrient, in which case Dr O'Hare says that can make it easy to look attractive to consumers.

"The orange colour in orange capsicum is zeaxanthin, which is important for slowing the progress of age-related macular degeneration. Purple and red anthocyanin pigments have been linked to improving cardiovascular health. So, increasing purple colour also increases the health value of vegetables."

Purple power

Dr O'Hare began creating purple sweet corn a couple of years before Naturally Nutritious was established; however, he believes the project can make the development of a supermarket product move forward faster.

"The difficulty is that the natural mutation that makes sweet corn 'supersweet' is positioned extremely close to the mutation that 'blocks' purple pigment production. The challenge was to break this tight genetic linkage, so that the supersweet mutation is now alongside a 'working' part of the anthocyanin purple pigment pathway," he says.

"The good news is that we have done this for two different 'supersweet' mutations now, including 'shrunken-2', which the Australian sweet corn industry and much of the world is based upon."

Dr O'Hare and his team are currently developing molecular markers, or fragments of DNA, to help accelerate their future research.

"This is important if we want to introduce other commercial aspects in the future, such as disease resistance, from yellow sweet corn into the purple sweet corn," he says.

Increasing health benefits

Dr O'Hare said the products may not necessarily replace artificial nutritional supplements; however, the research team's investigation into nutrient biofortification – or increasing nutrient content in produce – has produced promising results, including in purple sweet corn. It has also identified high folate strawberries, where a single punnet of strawberries will supply the recommended daily folate intake (four times higher than average).

"We have also identified orange capsicums that have the equivalent zeaxanthin content to 30 macular degeneration supplement tablets.

We are exploring the potential to make macadamia nuts even better for you than they are already. We are looking at purple strawberries, which may have different health benefits to regular strawberries, plus we're planning to extend the narrow season of the high-anthocyanin Queen Garnet plum, by bringing it forward into the Christmas festive season (it currently produces in February)," Dr O'Hare says.

"On top of that, we are undertaking consumer evaluation of the product concepts, and we also have a study on the comparative benefit of different fruit and vegetables, specifically which ones make you feel full faster and which make you last longer before wanting to eat again. This is all good for the waistline."

Next steps

Purple sweet corn will become available to Australia's vegetables growers following the issue of a public tender once the product is closer to a commercial hybrid.

"Not everything happens at once, but we are getting to the stage where different industries can decide if they want to take things further in separate focused projects; that is, beyond the proof-of-concept stage. We know that not everything will be a winner – some things would obviously suit 'niche markets' better, while others have wider market appeal.

"Horticulture includes so many crops that a single project simply cannot cover everything. We know there is so much more out there to achieve."

Original article 'Purple sweet corn - naturally nutritious!' published in *Vegetables Australia* - Spring 2019, page 54-55.

Image: Shutterstock

Crunching the data: Dr Heather Smyth, QAAFI, with Professor Jason Stokes, Deputy Associate Dean (RES) Faculty of Engineering, Architecture and Information Technology. Photo © UQ

Keeping the crunch in low-fat chips

University of Queensland chemical engineers have developed a new method to analyse the physical characteristics of potato chips in a bid to develop a tastier low-fat snack.

Professor Jason Stokes says while a low-fat potato chip might reduce guilt, many people don't find the texture as appealing.

"A key challenge in the food industry is reducing the amount of sodium, added sugar and saturated fat without sacrificing the taste, flavour, texture and mouthfeel in food and drink," Professor Stokes says.

"Even subtle changes in the composition of processed food and drink can alter the consumer's acceptability of a product for reasons that are not well understood, which compromises healthy choices."

Professor Stokes worked with flavour scientists including QAAFI's Dr Heather Smyth, USA researcher Dr Stefan Baier – now at Motif Ingredients – and former UQ postdoctoral researcher Dr Michael Boehm, who now works at PepsiCo, Inc.

The team has been developing a more objective method of analysing the potato chips at four stages of simulated eating.

"We wanted to simulate the entire eating process, from first bite, to the break down and softening of chip particles and finally swallowing the clumped mass of chip particles," he says.

The researchers used the results to design a lower-fat chip coated in a thin layer of seasoning oil that contained a small amount of a food emulsifier.

In tests with sensory panellists, the seasoning oil made the low-fat chip more closely resemble the greasiness of a full-fat one, but it added only 0.5 per cent more oil to the low-fat product.

Professor Stokes says he had worked with all manner of food and drink.

Gulkula nursery in East Arnhem Land have cultivated the first commercial/research Buchanania obovata *seedlings from the wild. Photo: Margaret Puls (UQ)*

Plum pickings: ancient fruit ripe for modern plates

An Indigenous fruit that is one of the earliest known plant foods eaten in Australia could be the next big thing in the bush foods industry.

The University of Queensland research team is led by bush foods researcher Associate Professor Yasmina Sultanbawa, who says the green plum not only tasted delicious but contained one of the highest known folate levels of any fruit on the commercial market.

"This is really exciting because folate is an important B-group vitamin, and what's great about the green plum is that the folate is in a natural form so the body absorbs it more easily than in a capsule," Dr Sultanbawa says.

Folate performs many functions in the body, including helping cells work and tissues grow, and is regarded as essential for the healthy development of the foetus during pregnancy.

Her team is undertaking the world's first detailed study of the nutritional characteristics of the green plum (*Buchanania obovata*).

"The green plum is sometimes called 'wild mango', and grows abundantly across the far north of Australia," Dr Sultanbawa says.

"There is recent evidence discovered in West Arnhem Land which shows the green plum was eaten by Aboriginal people as far back as 53,000 years ago."

With funding from the Australian Research Council's Industrial Transformation Training Centre's program for Uniquely Australian Food, Dr Sultanbawa is working with Aboriginal communities in East Arnhem Land and Delye Outstation in the Northern Territory to research the green plum.

Ms Selina Fyfe, a food scientist who is undertaking a PhD on the green plum, says the sensory qualities of the green plum are outstanding.

"It's probably one of the most delicious foods I have ever tasted – it's very sweet, a bit like stewed fruit," Ms Fyfe says.

"The research has already found the green plum's flesh is high in protein, dietary fibre, folate, potassium and is a good source of magnesium, calcium and phosphorous."

The seed of the green plum is also rich in dietary fibre, iron and vitamin B9.

The green plum belongs to the family *Anacardiaceae,* which contains well-known commercialised fruit including mango, cashew apple, and pistachio nuts.

International collaborators work with QAAFI to research green plum in East Arnhem Land: (L-R) A/Prof Dharini Sivakumar, Tshwane University of Technology, South Africa; Prof Philippe Schmitt-Kopplin from Helmholtz Zentrum München and Technical University of Munich in Germany; Kevin Wanambi, Gulkula Mining Company Pty Ltd; Ms Selina Fyfe, UQ; Maylla Wunungmurra, Gulkula Mining Company Pty Ltd; A/Prof Yasmina Sultanbawa, QAAFI. Photo: Margaret Puls © UQ

"The green plum is a sweet fruit that consistently rates highly in the consumer taste tests we've run in Brisbane and could one day be as popular as table grapes," Dr Sultanbawa says.

"A lot of people don't know about the green plum, even within the bush foods industry.

"This is a wild-harvested, seasonal fruit that typically ripens after the first rains of the wet season in late November/early December."

The fruit is eaten raw from the tree or as dried fruit, and the plum's flesh and seed can also be mashed into an edible paste.

Dr Sultanbawa says the green plum was traditionally used as food and medicine in Aboriginal communities across the Top End of Australia and was very popular with the children and elderly.

"The green plum has so much goodness, it could one day help with dietary issues like the triple burden of malnutrition – undernutrition, obesity and micronutrient deficiencies – known as hidden hunger," Dr Sultanbawa says.

"Our collaborators at the Aboriginal-owned Gulkula nursery in Gove, East Arnhem Land, have recently successfully propagated the green plum – and we believe this is the first time the plum has been propagated anywhere in the world.

"The Arnhem Land Progress Aboriginal Corporation for the first time did a trial harvest of the green plum this year."

The UQ team, which includes Dr Heather Smyth, Dr Michael Netzel and Dr Horst Schirra, is working with Professor Philippe Schmitt-Kopplin from the Technical University of Munich and the Helmholtz Zentrum München, and Professor Michael Rychlik from the Technical University of Munich to uncover the green plum's chemistry, and its acids and sugars, to provide a more detailed nutritional profile of the fruit.

"Once we get the scientific evidence about its nutritional value, chemical composition, the different maturity stages, and best time to harvest, then we can work with the communities to get it into the market as a commercial product."

Dr Sultanbawa says legal and social science researchers, and other partners in the ARC Centre for Uniquely Australian Foods, would work with Indigenous communities to undertake enrichment planting and develop enterprises that ensure Indigenous community ownership and control.

This research is supported by Arnhem Land Progress Aboriginal Corporation, Gulkula Mining Corporation, Dhimurru Rangers, Mata Mata Homelands, Wild Orchard Kakadu Plum Pty Ltd and funding from the Australian Research Council, The University of Queensland, the Department of Agriculture and Fisheries, Australian Native Food and Botanicals, the Kindred Spirits Foundation, Karen Sheldon Catering, Beeinventive Pty Ltd, and Venus Shell Systems Pty Ltd.

Employees grease hams with lard before hanging them to dry in storage as part of the Parma ham curing process in Langhirano, Italy. Pic: Shutterstock

Creating a science-based provenance for Australian food

Identifying the unique flavours and characteristics of Australian-grown food

Without the food traditions and heritage of Europe, where provenance is integral to marketing – think hams from Parma, Italy, or cheese from Cheddar, England – Australia is turning to science to identify, verify and tell the stories of its own unique food provenance.

QAAFI nutrition and food scientists are driving research in this area, to define what sets Australian food apart from other countries' products.

A food's volatile molecules that make up its distinctive smell and taste, for instance, comprise only a tiny portion of its total composition, less than 0.1 per cent. But these molecules are also a key focus of sensory food science at QAAFI, which is working to identify the signature smell and flavour of Australian-sourced foods and how these differ from international competitors.

Director of QAAFI's Centre for Nutrition and Food Sciences Professor Mike Gidley says the move to provenance is essential to differentiate Australia from other countries, and to build on our reputation for 'clean, green' food production as a benchmark for marketing.

Smells and flavours may be part of these unique characteristics, he says, but there could also be functional properties, such as vitamin content or other health and nutrition characteristics.

Defining provenance

Although geographic indicators are widely recognised as providing provenance, there is no set list of characteristics that define it. However, provenance attributes must be distinctive and verifiable.

"We've set ourselves up to measure foods in many different ways, and our purpose in developing provenance profiles is to help de-commoditise Australian produce, to make sure as much as possible has added value," Professor Gidley says.

Plants and animals known to be unique to Australia, and the properties they offer, provide clear examples of provenance, but QAAFI is also investigating other less direct provenance stories.

These could relate not only to what plant or animal it is, but also to where it grows, who grows it, and what the production and processing systems are.

He says one approach is to show provenance with muscle foods (meat and fish) that are processed in Australia, where you are distinguishing muscle that has been put together by animals that have grown on distinctive plants.

"Honey is another example, a secondary product from plants, and also floral gins. These are the low-hanging fruit in provenance, where you are capturing the local plants in a concentrated form – capturing the essence of it."

QAAFI research has already identified that Australian honey produced from native myrtle has antibacterial properties superior to that of the much-lauded New Zealand Manuka honey, making it highly valued for treating wounds and infection. Photo: Anna Osetroff

Native Australian honey 'superior to Manuka'

QAAFI research has already identified that Australian honey produced from native myrtle has antibacterial properties superior to that of the much-lauded New Zealand Manuka honey, making it highly valued for treating wounds and infection.

Associate Professor Yasmina Sultanbawa, who heads the ARC Centre for Uniquely Australian Foods, led this research.

QAAFI uses a combination of techniques to find measurable features that can be used to demonstrate and protect claims of uniqueness, including detailed chemical and molecular analysis and the creation of more general "flavour fingerprints".

Flavour fingerprints

Professor Gidley says the approach focuses closely on attributes that consumers value and respond to. It might be about the variety, the region, the local climate, the agricultural practices or the production system that's being used.

Digital technologies are also allowing more and more information emerging from analysis to be supplied with a product, which customers can interrogate for the characteristics they are interested in.

QAAFI's provenance research includes developing practical, non-invasive measurement tools that producers can use in the field, backed by real science, to support their supply chain and marketing technologies.

Professor Gidley says that for particular product types there may be opportunities to maximise the nutritional and sensory value in a way that can deliver benefits to the farmer as a supplier of the raw material, to the processor and brander as the people adding value, and to consumers in terms of nutritional value and value for money and their expectations of the food experience.

"The traditional argument against value adding onshore is that it's too costly. But if you're selling Australian wheat into Asia, by the time it has been made into noodles or bread, no one knows that it's Australian.

"You lose the intrinsic advantage you have with consumers who want Australian foods. At some point, based on the unique properties of an Australian product, it may become more advantageous to process locally.

"Where it is possible, we should look to build the credentials, the measurable features by doing things within Australia that lock it into an Australian product," he says.

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Dr Heather Smyth	Senior Research Fellow
Associate Professor Yasmina Sultanbawa	Principal Research Fellow
Dr Barbara Williams	Senior Research Fellow

QAAFI Honorary and Adjunct Appointments

Honorary Appointments

Associate Professor Rafat Al Jassim	Honorary Associate Professor
Dr Nadaf Altafhusain Balechand	Honorary Senior Fellow
Associate Professor Phillip Banks	Honorary Associate Professor
Dr Marcelo Benvenutti	Honorary Senior Fellow
Professor Frederik Botha	Honorary Professor
Dr Jason Brider	Honorary Fellow
Associate Professor David Butler	Honorary Associate Professor
Associate Professor James Carter	Honorary Associate Professor
Associate Professor Yashvir Chauhan	Honorary Associate Professor
Dr Ian Chivers	Honorary Senior Fellow
Dr Marisa Collins	Honorary Senior Fellow
Dr Sushil Dhital	Honorary Senior Research Fellow
Dr Sandra Dunckel	Honorary Fellow
Dr Guangli Feng	Honorary Research Fellow
Dr Glen P Fox	Honorary Senior Lecturer
Professor Elliot Gilbert	Honorary Professor
Professor Roslyn Gleadow	Honorary Professor
Dr Yingbin He	Honorary Senior Fellow
Professor Mario Herrero	Honorary Professor
Professor Wayne Jorgensen	Honorary Professor
Professor Kemal Kazan	Honorary Professor
Associate Professor Athol Klieve	Honorary Associate Professor
Associate Professor Stan Kubow	Honorary Associate Professor
Professor Prakash Lakshmanan	Honorary 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 Ali Mohammad-Moner	Honorary Research Fellow
Professor Stephen Moore	Emeritus Professor
Dr Jessica Morgan	Honorary Fellow
Dr Miranda Mortlock	Honorary Senior Fellow
Dr Simone Osborne	Honorary Senior Fellow
Professor Hanu Pappu	Honorary Professor
Professor Graham Plastow	Honorary Professor
Dr Parimalan Rangan	Honorary Senior Research Fellow
Dr Vishal Ratanpaul	Honorary Fellow
Dr Hannah M Robinson	Honorary Fellow
Professor 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
Associate Professor Dharini Sivakumar	Honorary Associate Professor
Professor Roger Swift	Emeritus Professor
Professor Rajeev Varshney	Honorary 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
Dr Norhasnida Zawawi	Honorary Senior Fellow

Adjunct Appointments

Associate Professor Graham Bonnett	Adjunct Professor
Dr Bruce D'arcy	Adjunct Senior Fellow
Professor John Dixon	Adjunct Professor
Dr Rosalind Gilbert	Adjunct Fellow
Dr Lisa-Maree Gulino	Adjunct Fellow
Professor Wayne Hall	Adjunct Professor
Associate Professor Philippe Herve	Adjunct Associate Professor
Associate Professor Mark Hickman	Adjunct Associate Professor
Associate Professor Dr David Innes	Adjunct Associate Professor
Associate Professor Robert Karfs	Adjunct Associate Professor
Professor Vicki Lane	Adjunct Professor
Associate Professor Zivile Luksiene	Adjunct Associate Professor
Associate Professor William Macleod	Adjunct Associate Professor
Professor Cathrine Mcintyre	Adjunct Professor
Associate Professor Sarah Meibusch	Adjunct Associate Professor
Dr Kodanda Mereddy	Adjunct Senior Research Fellow
Dr Selina Ossedryver	Adjunct Fellow
Dr Diane Ouwerkerk	Adjunct Fellow
Dr Sambasivam Periyannan	Adjunct Senior Fellow
Professor Gregory Platz	Adjunct Professor
Dr Richard Silcock	Adjunct Senior Fellow
Associate Professor Youhong Song	Adjunct Associate Professor
Dr Michael Sweedman	Adjunct Fellow
Dr Santosh Taware	Adjunct Senior Fellow
Professor Leena Tripathi	Adjunct Professor
Professor Lynne Turner	Adjunct Professor
Associate Professor Lizzie Webb	Adjunct Associate Professor
Associate Professor Neil White	Adjunct Associate Professor
Dr John Wilkie	Adjunct Senior Fellow
Associate Professor Rex Williams	Adjunct Associate Professor
Professor Graeme C Wright	Adjunct Professor

QAAFI Affiliates

Professor Steve Adkins	Affiliated Professor
Professor Elizabeth Aitken	Affiliated Professor
Professor Stephen Barker	Affiliated Professor
Professor Michael Bell	Affiliated Academic
Professor Christine Beveridge	Affiliated Professor
Professor Jimmy Botella	Affiliated Professor
Professor Wayne Bryden	Affiliated Professor
Professor Bernard Carroll	Affiliated Professor
Professor Scott Chapman	Affiliated Professorial Res Fellow
Dr Mark Dieters	Affiliated Academic
Dr Marina Fortes	Affiliated Research Fellow
Associate Professor Michael Furlong	Affiliated Associate Professor
Associate Professor Victor Galea	Affiliated Associate Professor
Associate Professor John Gaughan	Affiliated Associate Professor
Professor Elizabeth Gillam	Affiliated Professor
Associate Professor Peter Kopittke	Affiliate Principal Research Fellow
Professor Neal Menzies	Affiliated Professor
Dr Anne Sawyer	Affiliate Research Officer
Professor Peer Schenk	Affiliated Professor
Professor Susanne Schmidt	Affiliated Professor
Associate Professor Kathryn Steadman	Affiliated Associate Professor
Associate Professor Mark Turner	Affiliated Associate Professor
Dr Olivia Wright	Affiliate Research Fellow
Professor Gordon Xu	Affiliate Professorial Fellow

QAAFI Operational and Technical Staff

Carol Ballard	Centre Manager - ARC Training Centre
Maria Caldeira	Health, Safety and Facilities Officer
Suzanne Campbell	Centre Administration Officer/Coord
Dr Errol Corsan	Principal Plant Improvement Consult
Annie Cox	Executive Assistant
Peter Devoil	Principal Farming Systems Modeller
Cameron Doig	Research Development Officer
Liz Eden	Administration Officer (Marketing)
Dr Madeleine Gleeson	Research Assistant
Susie Green	Research Project Support Officer
Tyne Hamilton	Marketing and Communications Officer
Aaron Hughes	Facility Infrastructure Coordinator
Elizabeth Humphries	Health, Safety and Facilities Manager
Ritesh Jain	Research Assistant
Jackie Kyte	Project Manager - Events
Shannon Landmark	Research Assistant - Beef Breeding
Emma Linnell	Executive Assistant
Janelle Low	Centre Administration Officer/Coord
Dr Narelle Manzie	Senior Research Project Officer
Carolyn Martin	Marketing and Communication Manager
Cassie Martinez	Administrative Officer
Sandra Micallef	Data Manager
Annie Morley	Executive Assistant – Institute Director
Joseph Murdoch	Community and Industry Engagement Officer
Christopher O'Brien	Research Assistant
Cecilia O'Dwyer	Senior Research Technician
Akila D Prabhakaran	Research Assistant
Lara-Simone Pretorius	Research Assistant
Margaret Puls	Senior Communications Officer
Sean Reynolds Massey-Reed	Research Technician
Vivian Rincon Florez	Senior Research Technician
David Rodgers	Senior IT Support Officer
Melissa Rowan	Centre Administration Officer/Coord
John Sheppard	Plant Improvement Consultant
Dr Francesca Sonni	Research Assistant
Reema Singh	Research Assistant
Angie Strewlow	Centre Administration Officer/Coord
Julianna Thomson	Research Project Support Officer
Hanna Toegel	Assistant Research Technician
Bronwyn Venus	Research Partnerships Manager
Stephen Williams	Deputy Director
Corey Worcester	Operations Manager
Elizabeth Worrall	Research Assistant
Melissa Yap	Centre Administration Officer
Wen Yee	Research Assistant
Dagong Zhang	Senior Research Assistant
Fiona Zhao	Grant Administration Officer

QAAFI Higher Degree by Research Candidates

Centre for Animal Science

Name	Program	Supervisor	Project Title
Sadia Chowdhury	PhD	AsPr Mary Fletcher	Authentication of uniquely Australian food products with claimed health benefits
James Copley	MPhil	Prof Benjamin 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	AsPr 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 Kabanowicz	PhD	Prof Ala Tabor	Biotechnological approaches to identify vaccine antigens in economically important ticks: Yeast Display and Proteomics
Ai Hwee Kho	PhD	Dr Peter James	Rapid detection of nematodes in sheep and goats using near-infrared spectroscopy (NIRS)
Zhi Hung Loh	PhD	AsPr 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
Aaron Schulze	MPhil	AsPr Mary Fletcher	Bio-actives:Value-adding to Industrial Hemp Production
Xiaochen Sun	PhD	Dr Cornelia Turni	Studies on Glaesserella australis
Christie Warburton	PhD	Prof Benjamin 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	Dr Geoffry Fordyce	PhD Analgesia and Haemostasis to achieve high standards of beef calf welfare in northern Australia
Seema Yadav	PhD	Prof Benjamin Hayes	Optimising genomic selection in sugarcane

Centre for Crop Science

Name	Program	Supervisor	Project Title
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 transpiration efficiency in wheat to enhance future breeding
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 Nageswararao Rachaputi	Physiological constraints to yield of mungbean iin 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	Genomics of sugarcane bioenergy traits
Colleen Hunt	PhD	Prof David Jordan	Statistical analysis of sorghum breeding trials with complex genetic components
Dilani Jambuthenne Gamaralalage	PhD	AsPr Lee Hickey	Mining novel genes for adult plant resistance to stripe rust in wheat landraces
Asad Khan	PhD	AsPr Bhagirath Chauhan	Biology of Amaranthus retroflexus and Amaranthus viridis
Sana Khan	PhD	AsPr Lee Hickey	Accelerated genome editing to speed up genetic gain in crops
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 Joseph Eyre	Sorghum and maize establishment in cold and drying soils
Amy Mackenzie	PhD	Dr Sambasivam Periyannan	Protecting wheat from stripe rust disease through rapid transfer of resistance from landraces
Patrick Mason	PhD	Prof Robert Henry	Diversifying cane sugar production systems: identifying carbon petitioning in a number sugar cane varieties in order to optimize production for a number of processes
James McLean	MPhil	Prof Daniel Rodriguez	Proximal and remote sensing as tools 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	Discovery of molecular control of variation in carbon partitioning in sugarcane
Charlotte Rambla	PhD	Dr Lee Hickey	Optimising root systems in wheat
Dipika Roy	PhD	Dr Lee Hickey	Understanding the genetics of spot blotch resistance in barley
Mahendraraj Sabampillai	PhD	Dr 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 Sambasivam Periyannan	Molecular genetic characterisation of rust disease resistance genes from Valilov'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 Smuth	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	Dr Nageswararao Rachaputi	Development and application of molecular tools to identify pest and drought resistance traits in the Australian wild pigeonpea
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
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	Dr 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-defence
Grant Chambers	MPhil	AsPr Andrew Geering	Study of viroids in Australian citriculture
Daniel Edge-Garza	PhD	Dr Craig Hardner	Global prediction for genetic improvement of apple
Bao Tram Hoang	MPhil	Prof Neena Mitter	Molecular basis of topical dsRNA application in viral defence and pest resistance in crop plants
Ritesh Jain	PhD	Prof Neena Mitter	Topical application of RNA interference to manage insect pests of horticultural crops
Olumide Jeff-Ego	PhD	AsPr Olufemi Akinsanmi	Occurence and virulence of phytophthora species 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	Professor Bruce Topp	Application of genomics in Macadamia breeding
Mohamed Zakeel Cassim	PhD	AsPr Olufemi Akinsanmi	Unravelling the biotic cause and interaction of abnormal vertical growth in macadamia
Vheena Mohankumar	PhD	AsPr Olufemi Akinsanmi	Biology and epidemiology of Botryosphaeria associated with branch dieback and tree death in macadamia
William Nak	PhD	Prof Neena Mitter	Topical application of RNA interference to modulate plant gene expression
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 Nuruli	PhD	AsPr John Edwin 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 Akinyemi 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

Centre for Nutrition and Food Sciences

Full Name	Program	Supervisor	Project Title
Oladipupo Adiamo	PhD	AsPr 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	AsPr Yasmina Sultanbawa	Elucidating mechanisms of antimicrobial activity of Australian native plant extracts
Batlah Almutairi	PhD	AsPr Yasmina Sultanbawa	Extraction of oligosaccharides from Australian native food plants and its applications in probiotic food systems
Yeming Bai	PhD	Prof Michael Gidley	Mechanistic exploration of effects of ginseng (a traditional Chinese food additive and medicine) on the digestion rate of starch containing foods
Cindy Bermudez	MPhil	Dr Deirdre Mikkelsen	Visualisation and characterisation of microbe-solid food remnant interactions from in vitro fermentation experiments using porcine and human faecal inocula.
Eshetu Bobasa	PhD	AsPr Yasmina Sultanbawa	Evaluation of urolithins obtained from ellagitannins in Kakadu plum (Terminalia ferdinandiana)
Alexander Bui	PhD	Prof Michael Gidley	Design rules for nutritionally functional grains
Madan Chapagai	PhD	Prof Michael Gidley	Preparation and characterization of chemically modified wheat starch for selective adsorption during mineral flotation
Selina Fyfe	PhD	AsPr 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 Wu	PhD	Dr Timothy O'Hare	Endogenous fatty acid desaturation of palmitic to palmitoleic acid in macadamia kernel tissue.
Kodagoda Hitige Gethmini	PhD	Dr Michael Netzel	Assessment of the nutritional quality of Australian-grown Plumcot
Haiteng Li	PhD	Prof Michael Gidley	Gut microbial response to diverse forms of resistant starch
Caili Li	PhD	Prof Michael Gidley	High-amylose wheat flour as a functional food ingredient
Shiyi Lu	PhD	Prof Michael Gidley	Bacterial fermentation of cellulose-based composites as plant dietary fibre
Maximiliano Muller Bravo	PhD	Prof Eugeni Roura	Nutritional interventions in piglets to improve post-weaning health outcomes
Sharif Nada	PhD	Prof Robert Gilbert	Modelling Glycogen Structure and Metabolism
Kim Seng Galex Neoh	PhD	Prof Robert Gilbert	Assessing Australian wheat quality for Japanese ramen noodles
Thi Le Thoa Nguyen	PhD	Prof Robert Gilbert	Structure and Functionality of Oat Carbohydrates
Dongdong Ni	PhD	Prof Michael Gidley	Plant cell wall architecture and molecular organisation
Sharon Nielsen	PhD	Dr Glen Patrick Fox	Multiphase Design and Linear Mixed Model analysis of NIR scanning data
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	AsPr Yasmina Sultanbawa	Evaluation of natural antioxidant sources as functional ingredients in animal feed
Sarah Osama	PhD	Dr Glen Fox	Identifying genes for resistance to pre-harvest sprouting and black point in barley (Hordeum vulgare)
Apurba Lal Ray	PhD	Dr Timothy O'Hare	Genetic factors affecting anthocyanin development in purple-pericarp sweetcorn
Shammy Sarwar	PhD	AsPr Yasmina Sultanbawa	Innovative non thermal technologies for treatment of fungal contamination in strawberries
Maral Seidi Damyeh	PhD	AsPr 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 sorghum-based gluten-free pasta
Xiaoyan Tan	PhD	Prof Robert Gilbert	Structural features controlling germination and other functional properties of barley
Keyu Tao	PhD	Prof Robert Gilbert	Understanding the molecular mechanisms controlling sensory properties in starch containing foods
Shaoyang Wang	PhD	Dr Heather Smyth	A systematic approach to understanding wine texture and mouthfeel.
Widaningrum	PhD	Prof Michael Gidley	Microbial fermentation of insoluble plant dietary fibres.
Hong Yao	PhD	Prof Michael Gidley	Microbiome responses to food carbohydrates
Shaobo Zhang	PhD	Prof Robert Gilbert	Molecular Dynamics Simulation Study of Starch
Yingting Zhao	PhD	Prof Robert 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

Publications

Book

Godwin, I.* (2019) Good enough to eat?: Next generation GM crops. Cambridge, United Kingdom: Royal Society of Chemistry.

Wilkus, E., Roxburgh, C. & Rodriguez, D. (2019) Understanding household diversity in rural eastern and southern Africa. Canberra, ACT Australia: Australian Centre for International Agricultural Research.

Book Chapter

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Adkins, S.*, Shabbir, A. & Dhileepan, K. (2019) Conclusion. In Steve Adkins, Asad Shabbir, Kunjithapatham Dhileepan (Eds.), Parthenium weed: biology, ecology and mangement (pp. 303-314). Wallingford, Oxfordshire, United Kingdom: CAB International.

Alhambra, C., Dhital, S.*, Sreenivasulu, N. & Butardo, V. (2019) Quantifying grain digestibility of starch fractions in milled rice. In (Eds.), Rice Grain Quality (pp. 241-252). New York, NY, United States: Humana Press Inc.

Allan, S., Shi, B. & Adkins, S.* (2019) Impact of Parthenium weed on human and animal health. In Steve Adkins, Asad Shabbir, Kunjithapatham Dhileepan (Eds.), Parthenium weed: biology, ecology and mangement (pp. 105-130). Wallingford, Oxfordshire, United Kingdom: CAB International.

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Li, C., Li, H. & Gilbert, R.* (2019) Characterizing starch molecular structure of rice. In (Eds.), Rice Grain Quality (pp. 169-185). New York, NY, United States: Humana Press Inc.

Li, L.*, Zhou, C. & Xu, Z.* (2019) Self-nanoemulsifying drug-delivery system and solidified self-nanoemulsifying drug-delivery system. In Shyam S. Mohapatra, Shivendu Ranjan, Nandita Dasgupta, Raghvendra Kumar Mishra, Sabu Thomas (Eds.), Nanocarriers for drug delivery: nanoscience and nanotechnology in drug delivery (pp. 421-449). Amsterdam, The Netherlands: Elsevier Science.

Liu, G.*, Li, J. & Godwin, I.* (2019) Genome editing by CRISPR/Cas9 in sorghum through biolistic bombardment. In (Eds.), Methods in molecular biology (pp. 169-183). New York, NY, United States: Humana Press.

Najeeb, U.*, Tan, D., Sarwar, M. & Ali, S. (2019) Adaptation of Crops to Warmer Climates: Morphological and Physiological Mechanisms. In (Eds.), Sustainable Solutions for Food Security (pp. 27-50). Cham, Switzerland: Springer.

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Silva, L.*, de Sousa, D., de Sousa, R. & Ferrari, V. (2019) Beef cattle production in the Brazilian biomes. In Victor Roy Squires, Wayne L. Bryden (Eds.), Livestock: Production, Management Strategies and Challenges (pp. 163-188). Hauppauge, NY, United States: Nova Science Publishers.

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Voss-Fels, K.*, Herzog, E., Dreisigacker, S., Sukumaran, S., Watson, A.*, Frisch, M. et al. (2019) "SpeedGS" to accelerate genetic gain in spring wheat. In Thomas Miedaner, Viktor Korzun (Eds.), Applications of genetic and genomic research in cereals (pp. 303-327). Amsterdam, Netherlands: Elsevier.

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Journal Article

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Adiamo, O.*, Netzel, M.*, Hoffman, L.* & Sultanbawa, Y.* (2019) Acacia seed proteins: Low or high quality? A comprehensive review. Comprehensive Reviews in Food Science and Food Safety, 19(1): 21-43.

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