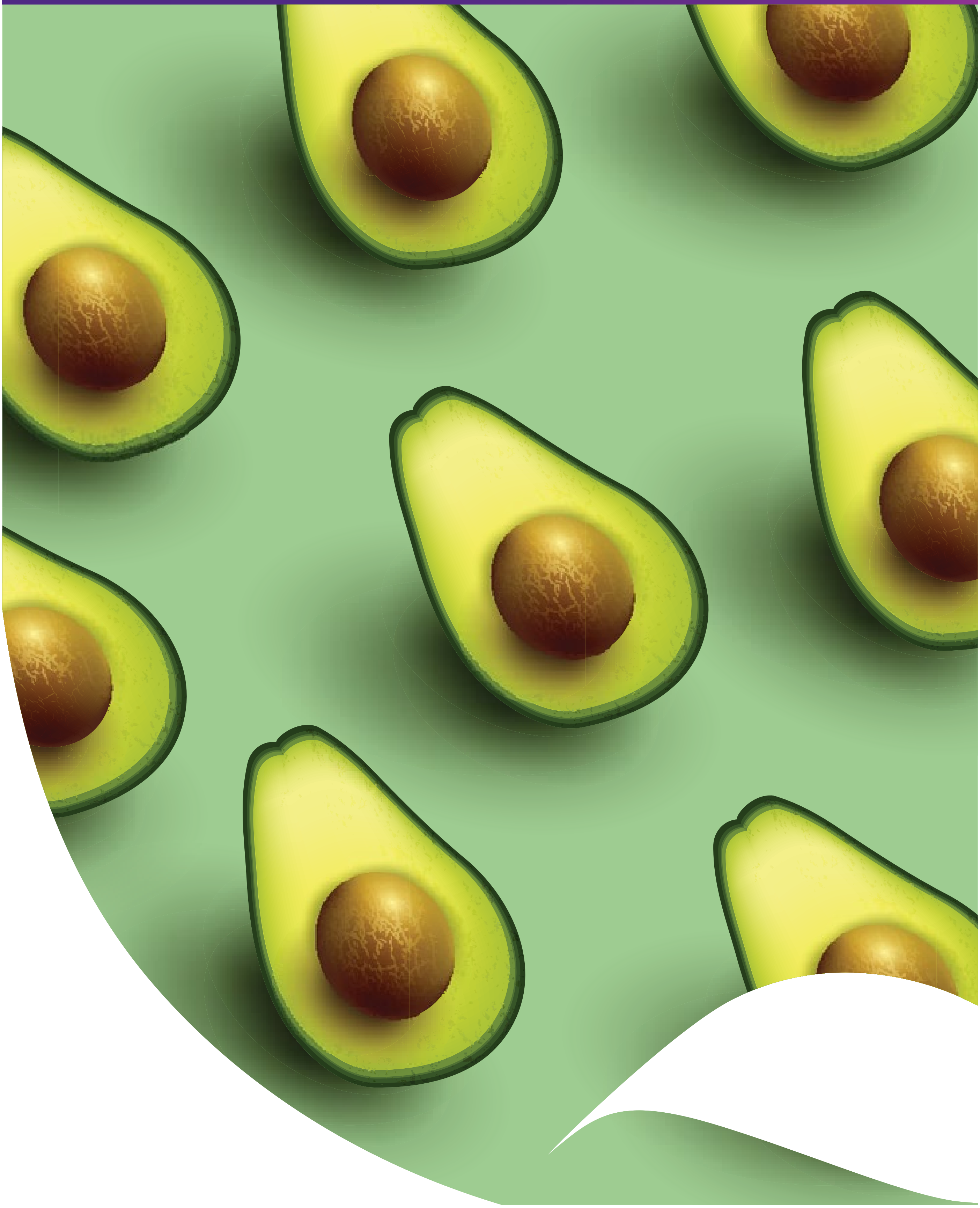
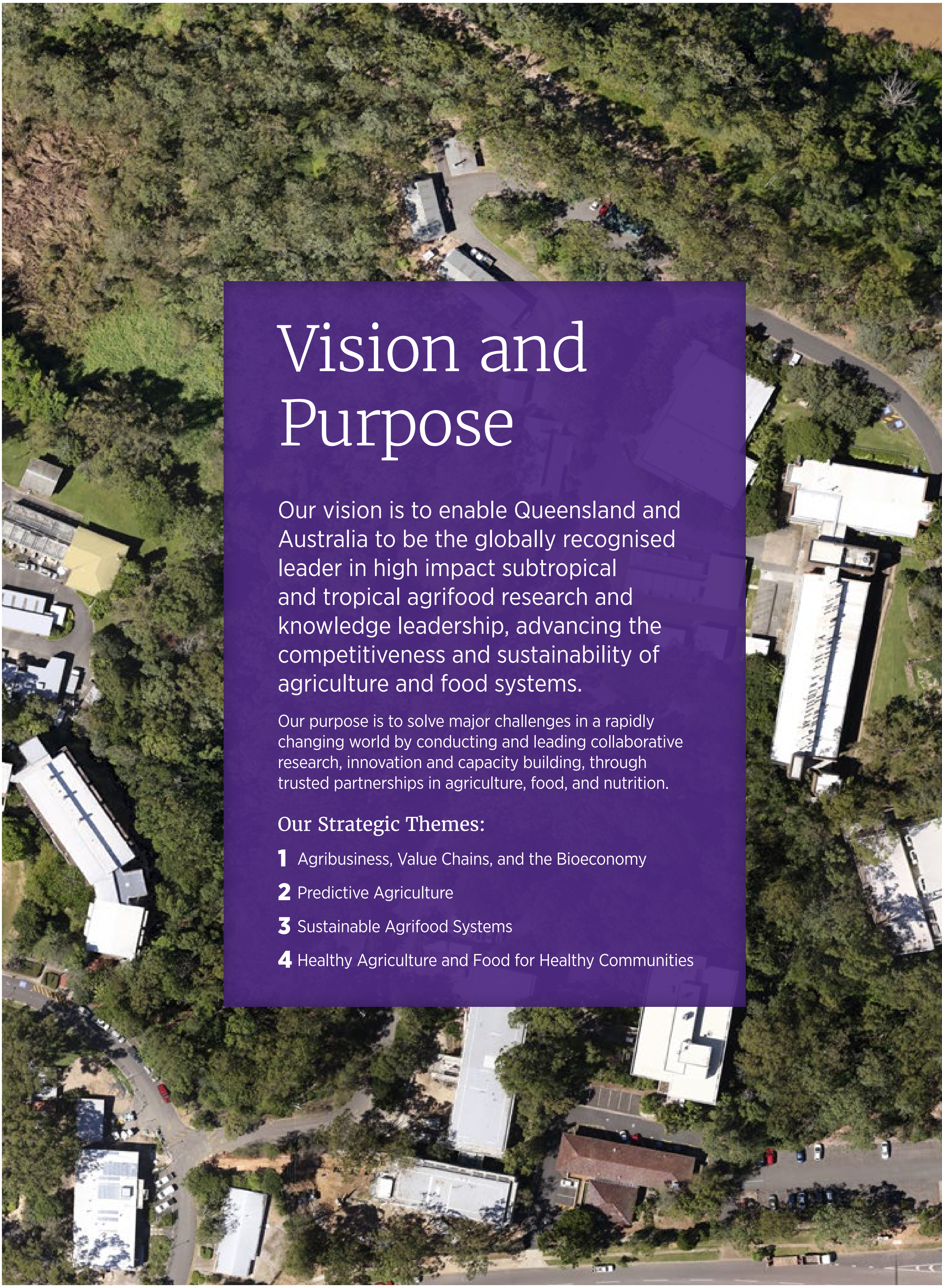
The University Of Queensland
AUSTRALIA

QAAFI
Queensland Alliance for Agriculture and Food Innovation

QAAFI in 2021





Vision and Purpose

Our vision is to enable Queensland and Australia to be the globally recognised leader in high impact subtropical and tropical agrifood research and knowledge leadership, advancing the competitiveness and sustainability of agriculture and food systems.

Our purpose is to solve major challenges in a rapidly changing world by conducting and leading collaborative research, innovation and capacity building, through trusted partnerships in agriculture, food, and nutrition.

Our Strategic Themes:

1. Agribusiness, Value Chains, and the Bioeconomy
2. Predictive Agriculture
3. Sustainable Agrifood Systems
4. Healthy Agriculture and Food for Healthy Communities

In 2021 QAAFI food system scientists moved into state-of-the-art food and nutritional research, and tissue culture facilities at the Elkhorn Building on UQ's Long Pocket campus in Indooroopilly, Brisbane. Aerial photo of Long Pocket campus © UQ.

Queensland Alliance for Agriculture and Food Innovation

QAAFI in 2021

Contents

Cover: 2021 was the UN's International Year of Fruits and Vegetables. QAAFI's 'avocado innovators' are helping secure a supply of the world's most favourite fruit, by developing the world's first Hass avocados produced by trees grafted from tissue culture plants. Read more about taking tissue cultured avocados from the lab to the orchard on page 49.

Cover image: Stock photo

Photo: Professor Matthew Morell (left), Professor Neena Mitter and Professor Bruce Topp at Maroochy Research Facility in Nambour.

Director's message

QAAFI's great reset

Professor Matthew Morell

My first year as Director of the Queensland Alliance for Agriculture and Food Innovation has been memorable.

Border closures, supply chain ruptures, not to mention droughts and flooding rains - agriculture is always in the frontline in extreme environments.

In 2022, QAAFI welcomes 11 new Research Higher Degree students, from Australia and as far afield as China, India, and Saudi Arabia. One student waited one and a half years to commence studies with us in 2022 – a testament to his tenacity, and wish to be part of Professor Yasmina Sultanbawa's Uniquely Australian Foods team.

In 2021 we welcomed Professor Michael Udvardi to the team in the newly created role of Professor of Legume Genomics. He is an expert in nitrogen fixation in legumes using biochemical, molecular, genetic, and genomic approaches.

Professor Damian Hine, an Evolutionary Economist who studies change and innovation processes, has joined QAAFI in another newly created and cross-disciplinary position, Leader of our Agribusiness, Value Chains, and the Bioeconomy research theme.

Recruitment of a Professor of Protected Cropping is underway; and for Professors in Sustainable Agrifood Systems and Animal Science.

These new positions reflect the need for innovation and expertise to harness powerful new biological tools in a complex food systems environment.

In this regard, we are delighted by the decision of the Senate of The University of Queensland to progress the Plant Growth Facility at St Lucia, an investment in plant science underpinning critical research in crop and horticultural science to the tune of over $45 million.

Our food and nutritional and tissue culture researchers moved into facilities at the Elkhorn Building on Long Pocket on 10 August 2021. Thank you to all involved in the move.

A key strength of QAAFI as a research provider is our alliance with the Department of Agriculture and Fisheries (DAF). We work with industry and government to support, diversify, add value, and help grow tropical and sub-tropical food systems in Queensland, which also often has benefit to the world, and vice-versa.

In 2021, the agriculture sector in Queensland achieved a rise of eight percent in the total value of primary industry commodities in 2020-21. The largest contributors by estimated GVP were meat products (47%); horticulture (22%); sugar (9%); and cereal products (8%).

QAAFI undertakes research across all these areas.

- Our animal scientists are now undertaking proof of trial concepts for simple on-the-spot genomic prediction tests to calculate breeding values on-farm for the northern beef industry.
- Our horticultural scientists are world leaders in clonal avocado propagation and cryopreservation of tropical and sub-tropical species.
- Our scientists played a key role in the global team that finally sequenced sugarcane's complex genome structure and we are working on a collaborative project to boost tonnages of sugarcane.
- Our cereal scientists this year published the world's first pan-genome for sorghum in a breakthrough for crop improvement and gene discovery and are leaders in gene-editing plants.

For QAAFI, 2021 was a year to take stock. We undertook a comprehensive review of our activities in close consultation with our alliance partner, DAF, staff, and industry, encapsulating the outcomes of this review in a new 2022-2025 Strategic Plan.

We created four new strategic themes, reflecting both our research strengths but also the complex and cross-disciplinary nature of modern food systems.

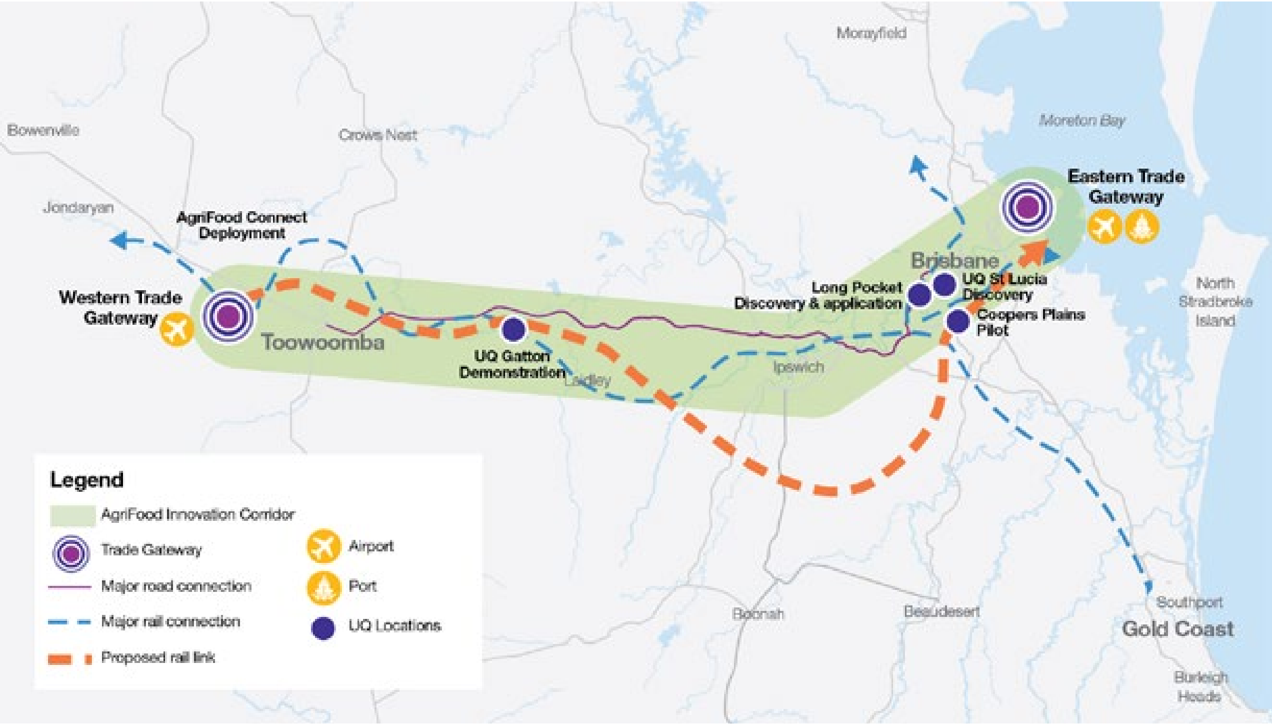
As Director, I have committed to addressing recommendations from the UQ and DAF reviews of QAAFI that fall within QAAFI's remit to address. By the end of 2021, these recommendations were fully addressed or have active time bound processes in place.

I wish all staff and students every success in 2022.

Professor Matthew Morell
Institute Director
Queensland Alliance for Agriculture and Food Innovation

Strengthening South–East Queensland's Agrifood Innovation Corridor

The Agrifood Innovation Corridor is a whole-of-UQ initiative lto strengthen research adoption across the agriculture and food sectors.



The aim is for research discoveries and early phase application occurring at UQ's various Brisbane based facilities, to be applied and demonstrated in UQ's facilities at Coopers Plains and Gatton, and deployed with commercialisation partners from the region, with a clear hub emerging in Toowoomba.

The initiative involves strategically planning infrastructure along the Agrifood Innovation Corridor as a rapid translation pathway, to accelerate the impact of research and innovation into food and agribusinesses across Queensland, Australia, and the globe.

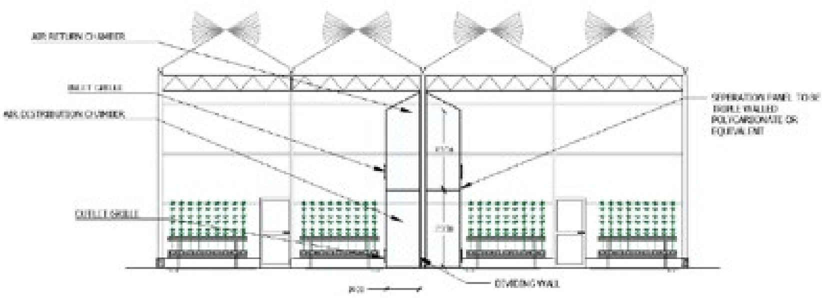
Initiatives underway include the St Lucia elite Plant Growth Facility, tissue culture and sensory food labs at the Long Pocket campus, the Gatton Masterplan, and Agrifood Connect, an industry collaboration precinct – in Toowoomba, where the new AgTech and Logistics Hub is sited.

AgriFood Connect is an industry shopfront at the Toowoomba end of the AgriFood Innovation corridor.

Plant Growth Facility at St Lucia

Construction is now underway for UQ's Plant Growth Facility at St Lucia, which is valued at over $45million. The build marks the first phase of the elite infrastructure investment strategy planned as part of the Agrifood Innovation Corridor initiative.

The Facility is a multi-function, temperature-controlled glasshouse and will complement planned investments in field and covered crop research and capability.



Vice–Chancellor's Message

Professor Deborah Terry AO

As our changing climate has an increasingly disruptive impact on global food production systems, one of the greatest challenges that humanity will face over the coming decades is producing enough nutritious food to feed the planet's growing population.

This issue is at the heart of much of the scientific research and collaborative innovation that occurs at the Queensland Alliance for Agricultural and Food Innovation (QAAFI), at The University of Queensland (UQ).

Over the past 12 years, QAAFI has established a reputation as a research and innovation powerhouse in the area of agriculture and food production systems.

Working in collaboration with government and industry, the team has contributed ideas, know-how, expertise, and invention – all founded on scientific research – that is making our agricultural and food manufacturing sectors more resilient, productive, and sustainable.

The COVID-19 pandemic (and the resultant disruption to global supply chains) has also served as a timely reminder that Australia needs to maintain sovereign capability in critical industry sectors – and most especially in agriculture and food manufacturing.

In this regard, the research that emerges from QAAFI is vital to strengthening the resilience of Australia's food production systems and protecting against future shocks to our food supply – regardless of whether that is caused by droughts, floods, crop disease, animal or pest plagues, or socio-political factors.

This year, QAAFI began to occupy the refurbished Elkhorn Building at our Long Pocket site, which is a major new base for food and nutritional research. The University also committed during 2021 to build a new Plant Growth Facility at St Lucia and new glasshouses for crop research at our Gatton campus. These investments are a demonstration of our faith in the high quality of QAAFI's research and its importance to human health and food security.

I'd like to convey my congratulations to Professor Matthew Morell, on the many achievements of the team during his first year at the helm as Director of QAAFI. I look forward to seeing how QAAFI continues to build on its many successes in 2022 and beyond.

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

Minister's Message

Hon Mark Furner

Congratulations QAAFI on a successful 2021.

The Department of Agriculture and Fisheries' (DAF) investment in research, development and extension, and our alliance with QAAFI has helped industry through a difficult year.

Queensland's agriculture sector has remained resilient in 2021, despite the challenges of COVID-19.

The ongoing relationship between QAAFI and DAF has helped us find real solutions that will help our community continue to prosper into the future.

QAAFI and DAF continue to work together to harness and explore ideas, and bring shared expertise and resources to tackling the challenges facing our sector and community.

We have also worked to ensure Queensland continues to be a world leading provider of high-quality, safe and sustainably produced food and fibre.

Moving forward, QAAFI and DAF will continue to support the sector to transform, making the most of supply chain changes that have resulted from COVID19.

In 2021-22, DAF is sharing funds of $8.097 million with University of Queensland/QAAFI to work together on key agricultural industry challenges.

Together, we will:

- tap into expertise from multiple organisations and disciplines to respond to issues facing the agricultural sector
- generate career pathways for scientists
- access additional networks of international scientists and state-of-the-art research approaches and equipment
- develop a platform to underpin increased tertiary training in agriculture in Queensland.

QAAFI and DAF are also helping to transition Queensland agriculture to net-zero, healthy, resilient, and profitable food systems by 2050.

We are working with QAAFI and UQ to identify solutions to the challenge of reducing Net Zero Emissions in the agriculture sector by 30% before 2030.

A review of the strategic alliance of QAAFI and DAF in 2021 revealed that QAAFI is performing very well and is a successful international leader in tropical and sub-tropical research.

Congratulations to QAAFI for assisting UQ achieve outstanding performance in agricultural research excellence, moving up the ranks to No.1 in Australia and 2nd in the world*.

**NTU Performance Ranking of Scientific Papers for World Universities, 2021.*

Hon Mark Furner
Minister for Agricultural Industry Development and Fisheries, Queensland

QAAFI: Delivering IMPACT

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

Income

$52M
Total external income in 2021

$409M
Total external income 2009 to 2025

$791M
Total actual and projected income to 2009-2026

People

456 People 2021

16 Higher degrees awarded 2021

142 Higher degrees awarded since 2014

Engagement

400+ Active projects 2021

256 Industry presentations, reports 2021

11 facilities in Queensland and **1** in China

Rankings

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

#1 in Agriculture in Australia, 2021*
NTU Performance Ranking of Scientific Papers for World Universities, 2021

#2 in Agriculture in the world, 2021
NTU Performance Ranking of Scientific Papers for World Universities, 2021

#1 in Agriculture in Australia 2021
QS World University Rankings by Subject

#26 in Agriculture in the world 2021
QS World University Rankings by Subject

Data figures as of 31 December 2021.

Heather's new role

Flavour chemist and sensory scientist from the Centre for Nutrition and Food Science, Associate Professor Heather Smyth, has been appointed Deputy-Director of Research at QAAFI.

The role assists the Director in oversight and strategic development of the research directions and research policies of QAAFI.

QAAFI's strategic research themes

Agribusiness, Value Chains & the Bioeconomy

- Improved profitability of agribusinesses
- Improved translation of research
- Innovation catalysing new businesses/sectors
- Optimised food systems & value chains
- Opportunity and demand driven research prioritisation
- Provenance and traceability
- Enhanced value of agricultural production
- Value addition on shore
- Indigenous/native foods

Theme Leader
Professor Damian Hine
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Predictive Agriculture

- Improved breeding systems
- Maximising yield
- Maximising performance under future climates
- Optimising GxExM
- Prediction of quality and value
- Decision support to maximise on seasonal and market fluctuation
- Remote sensing and data convergence

Theme Leader
Associate Professor Lee Hickey
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Sustainable Agrifood Systems

- Reduced environmental footprint
- Increased productivity per unit input
- Reduced methane and other GHG emissions
- Resilience in the face of climate variability
- Sustainable pastures and grassland-based animal production systems
- Reduced food waste
- Sustainable packaging

Theme Leader
Dr Barbara George-Jaeggli
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Healthy Agriculture & Food for Healthy Communities

- Reduced losses through plant and animal diseases
- Improved Biosecurity
- Animal welfare
- Nutrition driven approaches to improved animal productivity
- Improved food safety (absence of contaminants or anti-nutritionals)
- Improved nutritional outcomes from diets

Theme Leaders
Professor Yasmina Sultanbawa
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Associate Professor Femi Akinsanmi
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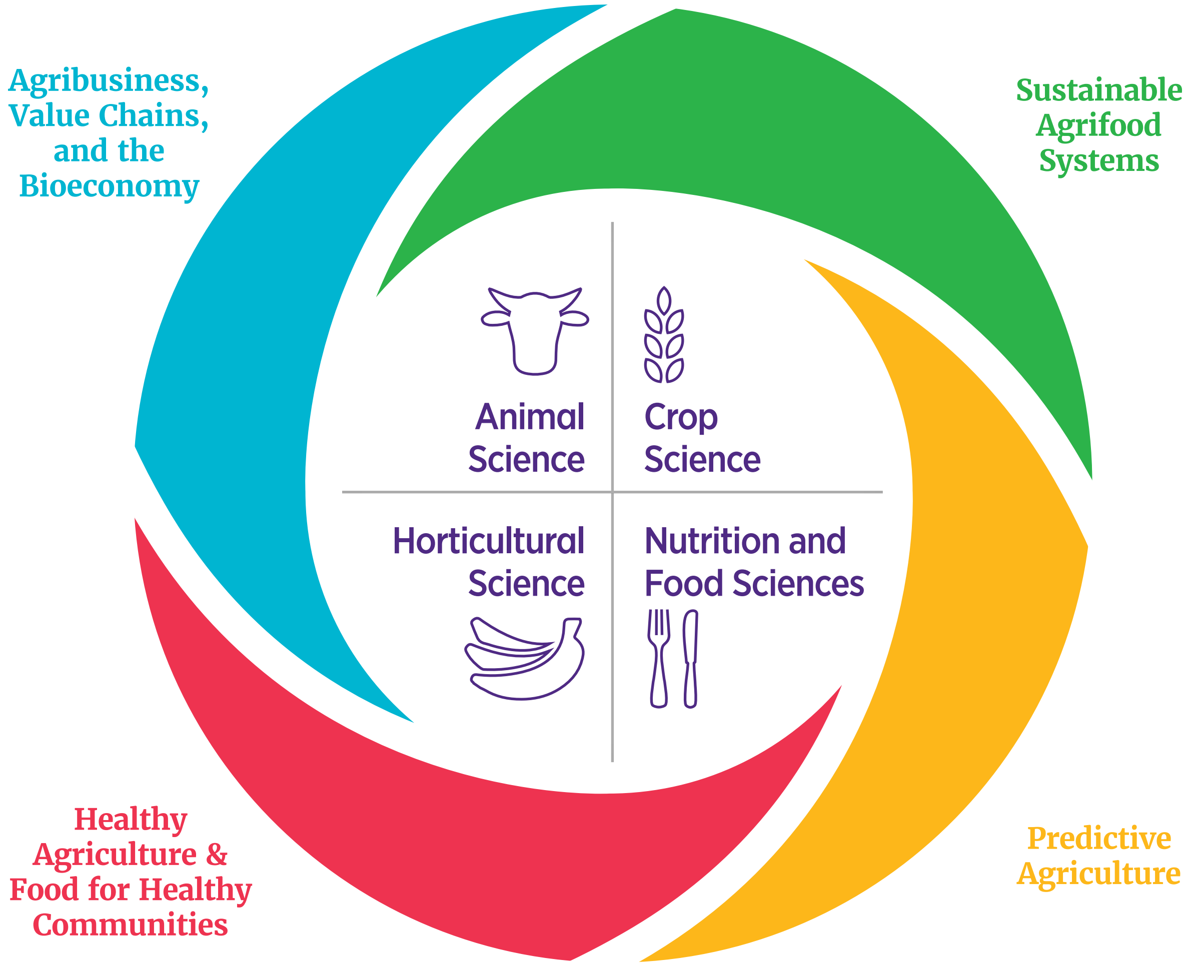
Research themes



CENTRE FOR
Crop Science

Capabilities

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

CENTRE FOR
Horticultural Science

Capabilities

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

CENTRE FOR
Nutrition and Food Sciences

Capabilities

- Smart selections
- Naturally nutritious
- Uniquely Australian

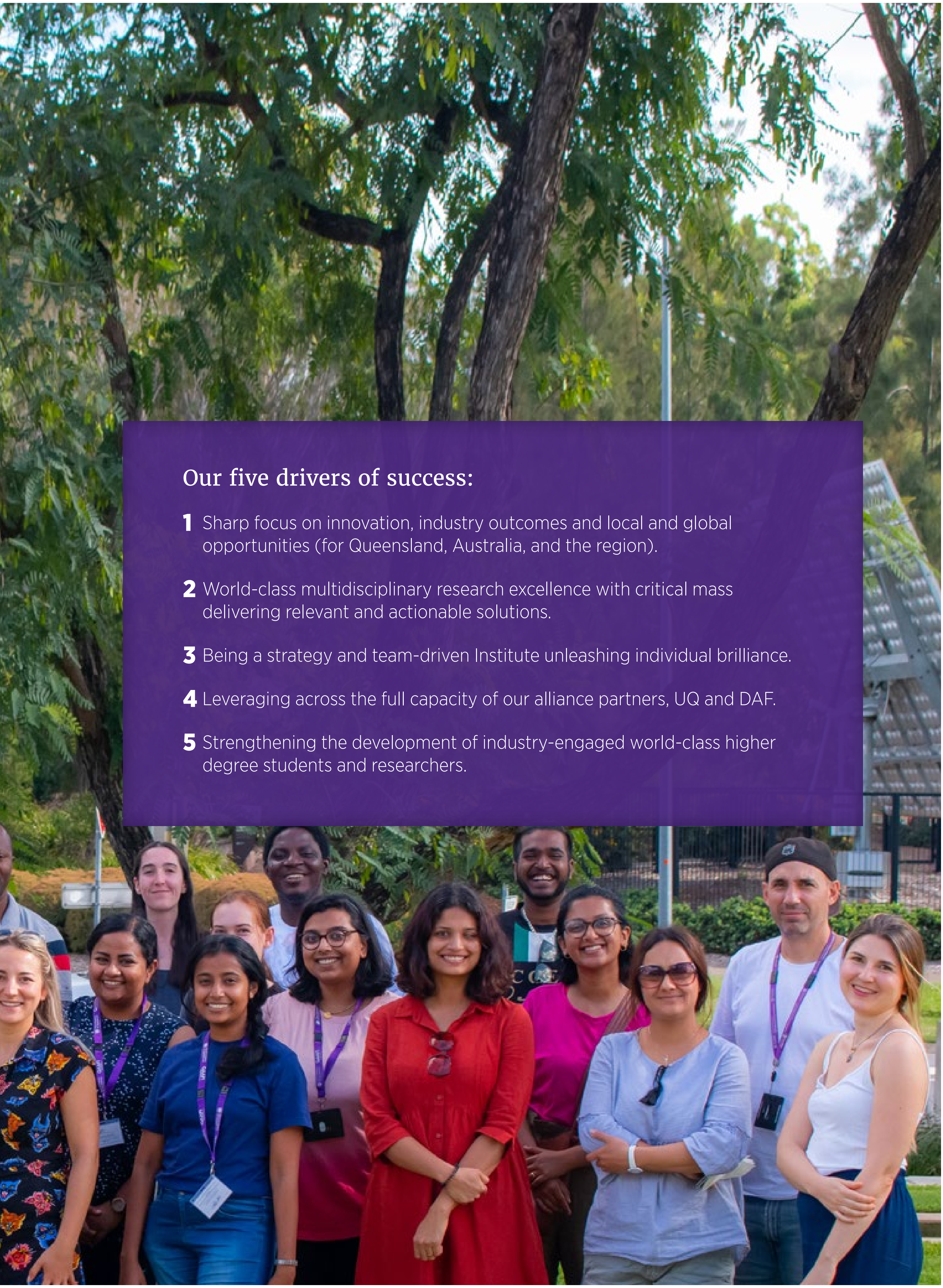
CENTRE FOR
Animal Science

Capabilities

- Pests and diseases
- Production systems
- Animal welfare

Research Excellence

QAAFI Higher Degree Research students in 2021



Our five drivers of success:

1. Sharp focus on innovation, industry outcomes and local and global opportunities (for Queensland, Australia, and the region).
2. World-class multidisciplinary research excellence with critical mass delivering relevant and actionable solutions.
3. Being a strategy and team-driven Institute unleashing individual brilliance.
4. Leveraging across the full capacity of our alliance partners, UQ and DAF.
5. Strengthening the development of industry-engaged world-class higher degree students and researchers.

Michael Udvardi
Professor in Legume Genomics

Professor Michael Udvardi received a PhD in plant biochemistry in 1989 from the the Australian National University (ANU) studying nutrient transport between legumes and rhizobia, which underpins symbiotic nitrogen fixation and sustainable agriculture.

Professor Michael Udvardi

After postdoc positions at Washington State University in the USA and at CSIRO Plant Industry in Canberra, he worked at the ANU before taking an Associate Professor position at the Max Planck Institute of Molecular Plant Physiology in Germany.

Between 2006 and 2021, Professor Udvardi worked as Professor then Director of Plant Biology at the Samuel Roberts Noble Foundation and finally as Chief Scientific Officer of the Noble Research Institute in the USA.

Throughout his research career he has focused on understanding symbiotic nitrogen fixation in legumes, using biochemical, molecular, genetic and genomic approaches in model, crop and forage legumes. He has also worked on associative nitrogen fixation, nitrogen transport, regulation of senescence, and abiotic stress tolerance in plants.

Solutions to chemical dependency and climate change in agriculture

A master innovator, Professor Udvardi, has joined the world-leading team of plant scientists at QAAFI to help mitigate crises stemming from agriculture's over-reliance on nitrogen fertilisers and climate change.

"To boost global production, soil fertility and the planet's nitrogen cycle among the key factors to get right," Professor Udvardi said.

"Ultimately all wealth rests on agriculture's ability to sustain production of healthy and affordable food."

At the base of the wealth pyramid are the staple crops that provide the foundation of diets for billions of people and livestock.

However, producing the yields required by a growing population requires nitrogen fertiliser. In turn, these chemicals require large amounts of fossil fuels to produce.

“Nitrogen fertiliser was essential fuel for the Green Revolution in the mid-1900s, which has staved off famine for millions but has created other problems,” Professor Udvardi said.

“The rich world uses an excess of fertiliser that results in atmospheric pollution and massive aquatic dead zones, even as a deficit among poor countries stunts economic development.”

In addition, fertiliser dependency makes food prices susceptible to the same price shocks that affect fuel prices, a recurring crisis currently about to repeat globally.

Legume benefits

As Professor Udvardi sees it, part of the solution are legumes – the pea- and bean-producing crops that are self-fertilising for nitrogen.

Legumes host microorganisms – called rhizobia – in root nodules that fix free nitrogen (N_2) into bioavailable forms that fertilise the plant and the soil for subsequent crops.

In return, the bacteria receive fixed carbon and other nutrients from their plant hosts in a classic example of a metabolic symbiosis.

“When I started out, the molecular biology and plant genetics of symbiotic nitrogen fixation was largely a mystery,” he said.

“Over four decades of innovation in research technology, there has been a dramatic gain in understanding.

“That work now makes it possible to breed legumes with improved nitrogen fixation and nitrogen-use efficiency (NUE) – a much-desired trait among breeders.

NUE is a trait that has important implications for long-term food security, environmental sustainability and prosperity.

That importance was recognised during the 1970s’ oil crisis and consequent high fertiliser prices. It prompted a generation of researchers, including Professor Udvardi, to explore the biochemistry and, eventually, the molecular biology and genetics of symbiosis.

Together with colleagues, he was the first to characterise transport properties of the membrane that separates rhizobia from the host cell cytoplasm, forming a pseudo-organelle called the symbisome.

During a postdoctoral research fellowship in the USA, Professor Udvardi used bacterial metabolic mutants and recombinant DNA technologies to isolate plant genes involved in nitrogen and carbon metabolism in legume nodules, another example of his ability to push research technology to a new level.

At the Max Planck Institute of Molecular Plant Physiology, developed technology platforms to interrogate genome-wide expression of genes in the model legume, *Lotus japonicus*, creating gene atlases associated with nodulation and nitrogen fixation.

These technologies were forerunners of the high-throughput functional genomics that dominate plant biology and breeding today.

Over the past fifteen years at the Noble Research Institute in the USA, Professor Udvardi expanded his research on symbiotic nitrogen fixation, using *Medicago truncatula* as a model species, to discover several genes that are crucial for symbiosis.

Additionally, his group explored plant responses to environmental stress, especially drought, at the transcriptional, metabolic and physiological levels, focusing on genotypes with contrasting stress tolerance levels.

Climate-resilient legumes for the sub-tropics

As his work acquired a more applied focus, Professor Udvardi accepted the newly created position at the University of Queensland – Professor in Legume Genomics.

He says the way agricultural research is performed at QAAFI is especially appealing due to a powerful integration of multiple disciplines, from genomics and physiology through agronomy and crop system modelling to plant breeding.

“The integration of disciplines not only connect molecular biologists with real-world challenges, but also provides an effective pathway to agricultural impact,” he said.

“It’s an approach with an impressive track record solving complex food production challenges that are otherwise difficult to overcome.”

He is keen to build up a research program that sits well within the priorities of QAAFI, legume breeders and Australian farmers.

He notes that legumes are an important component of crop rotations across Australia so that improved NUE and stress tolerance stand to improve productivity and yield stability in the face of climate change and decrease the reliance on chemical fertiliser.

In Queensland, farmers are already benefiting enormously from the inclusion of mungbean in crop rotations and work is underway at QAAFI to prepare pigeon pea as an additional heat- and drought-tolerant legume option.

For his part, Professor Udvardi will be characterising the pan-genomes of important tropical legumes – a technique that uses genome sequencing technology to identify naturally occurring genetic variation that can boost agricultural productivity.

He then plans to use the full genetic potential of target species to develop the next generation of nutrient-efficient, climate resilient legume crops for Australia by working closely with plant physiologists, agronomists, modelers and breeders.

“Making it easier to grow more legumes in our cropping system will help solve so many problems because with legumes, you get an impact across the farming system especially via the nitrogen cycle,” Professor Udvardi said.

Mungbeans

Damian Hine
Professor of Future Markets and Bioeconomies

Professor Hine is an Evolutionary Economist who studies change and innovation processes. He leads QAAFI's cross-disciplinary Agribusiness, Value Chains & the Bioeconomy research theme.

Professor Damian Hine

Professor Hine has been an advisor to the World Bank, developed industry investment plans for Hort innovation, undertaking national studies on productivity in horticulture, regulation in digital health, freight and logistics, and investment in the biotechnology sector.

Professor Hine has collaborated with the OECD, World Bank, UNESCO, and international research with ACIAR, The Pacific Community, innovation and commercialisation for the Vietnam and Chilean governments. He has also worked with the FAO on water scarcity and cross-border solutions to water security and food security and helped design a major international project with the FAO on modelling the trade-offs between the sustainable development goals for FAO funded and operated projects.

The challenge to reset the value of farming

As a specialist in the economics of innovation, Professor Hine's goal is to get new funding into the agricultural sector.

He plans to link the experience, capacity, and potential of Australian agriculture with the national and global investment needed to take Australian farming to new levels of productivity, sustainability, diversity, and value.

"Achieving this means better connecting research 'push' with market 'pull' by attracting investment into industry-building partnerships that link agricultural science, farming, and new agriculture value chains," Professor Hine said.

"There is patient capital with sufficient risk appetite ready and waiting – institutional and philanthropic investment, and sovereign wealth funds, for example – wanting to invest in innovative agriculture.

"And at QAAFI and The University of Queensland we have excellent industries and excellent science that is looking for this support. The gap in between them is what we have to bridge."

This requires innovations and new business models that represent strong value propositions for investors and for growers.

Farming redefined

An example of the type of opportunity he hopes to develop is in protected cropping.

"With protected cropping in large-scale controlled environment facilities, we're not just talking about growing human food more securely and productively, but also crops that are feedstock for nutraceuticals and pharmaceuticals, for supplements, and high-value inputs into industrial processes," Professor Hine said.

"These represent big potential uplifts in value, but we first have to build the value chains to get these products and applications where they are needed – and that means bringing the science and the investment together as early in the development cycle as possible.

"We're talking, eventually, billions of dollars, but our target over the next few years is to generate investment levels in at least the hundreds of millions as a start."

Professor Hine says part of the groundwork for this will be working with producers and industry to establish more finessed agribusiness

Protected cropping in large-scale controlled environments offers opportunities for the bioeconomy. Stock image.

models that bring producers, manufacturers, and consumers closer together and more in sync with each other's value propositions.

"At the heart of better business models is the objective of achieving greater long-term returns to growers," he said.

He sees this as being central to increasing the uptake of advanced production technologies necessary to help better integrate farm production with end users, including consumers.

He said the digital era has ushered in a wave of new technologies with the potential to facilitate this integration, but the uptake of system changes such as precision agriculture, machine learning and predictive analytics remains modest in Australia compared to many other countries.

"Uptake of these technologies depends on their appropriateness to the needs of the growers and their financial constraints," Professor Hine said.

"It is therefore critical to rethink agriculture's business models to ensure they encourage, not discourage, the adoption and adaptation of technology.

"That means making sure research outputs are appropriate to a farm, its current and future needs and its budget – and is communicated as such."

King data

One of the keys to a higher-value agriculture is data.

"Data capture, analysis and use, particularly on-farm, will dictate the uptake and use of digital technologies in their various forms," Professor Hine said.

Data is what will make these technologies useful, timely and accessible. Data also allows evidence-based decision-making and helps build a long-term view to support strategic management.

"And when this happens you start thinking about the business models that the farm and the entire range of subsectors in agriculture are operating under and whether they are appropriate – for the immediate concerns around production and profit, and for longer-term intergenerational asset building.

For Professor Hine, agriculture's primary asset is land, and it is growing the value and sustainability of this asset that drives, or should drive, the appropriateness, use of and value of technology.

"We are at a point where few people would argue about the need for producers to increase the value of their prime asset, and for investment in agriculture to generate higher returns.

"If we accept that agriculture needs new business models to achieve this, the value questions must be asked: how do you create value, how do you deliver that value and, critically for producers, how do you capture more of the value you have created?

"Traditionally, farming does a pretty good job at creating value and not as well at capturing it. There's a lot of leakage along the supply chain. And we need producers capturing more of that value to stimulate the uptake of the technologies, strategies and practices we need for the sector to advance."

Professor Hine said one long-discussed approach is to develop more value-adding and processing capabilities coupled with shortened supply chains, but this requires a focus shift from the commodity to the consumer.

"That takes time and money, but other countries are already taking this lead, so we need to follow.

"We are under increasing environmental and trading pressures that are making it difficult to maintain productivity and profitability, so changes have to be made to the commodity business model. This requires a clear strategy and significant investment.

"So, a lot of my job is to facilitate this – to work on the 'translation and commercialisation' of new ideas and technologies, including the significant innovations that originate on our farms, as well as from our researchers."

Professor Hine feels agriculture has, at times, lagged when it shouldn't have.

"Agriculture has quality people and lots of opportunities, but there has been that disconnect between science and practice.

"It is getting better, but nowhere near to the extent that we're seeing in other countries. We have some catching up to do."

Promoting COMMUNITY

Professor Mary Fletcher won the 2021 UQ Award for Excellence in the Community, Diversity, and Inclusion category, which recognises outstanding effort in promoting equity, diversity and inclusion within UQ and proactively enhancing a sense of community among staff, students and partners.

UQ's Awards for Excellence are annual awards recognising and celebrating individuals and teams in the areas of innovation, service, diversity and inclusion, wellness and safety, and leadership.

Mary was a founding member of QAAFI's first Equity and Diversity Committee and helped drive several policies that have greatly benefited our staff and the culture of our Institute.

These include the introduction of a primary care givers framework, which provided support to several QAAFI Early Career Researchers to travel to conferences and attend project meetings.

Mary was a member of the UQ team that invested countless hours into the Athena Swan Pilot. This work led to UQ's successful submission for the Athena Swan Bronze Award – and Mary has certainly been a leading figure in implementing Athena Swan at QAAFI.

Congratulations Mary!

QAAFI's GENE QUEEN

Professor Neena Mitter (pictured centre) received Life Sciences Queensland's Rural and Regional Service Award on 19 November 2021, one of Life Sciences Queensland (LSQ) Globally Engaging Networking Event (GENE) Awards. Professor Mitter was also shortlisted in the QIMR Berghofer Woman of Influence Award.

The GENE awards recognise outstanding leaders in Life Sciences and their ongoing achievements across a range of categories.

Pictured are (left to right) Clare Blain, CEO of Life Sciences Queensland; Professor Colleen Nelson AM, recipient of LSQ QIMR Berghofer Woman of Influence Award; Dr Fleur Garton, recipient of The Rose-Anne Kelso Commemorative Award; Professor Neena Mitter, recipient of the LSQ Rural and Regional Service Award and Highly Commended in LSQ QIMR Berghofer Woman of Influence Award; Professor Ian Frazer AC recipient of LSQ Hall of Fame Award; Dr Patrick Silvey, recipient of McCullough Robertson Industry Excellence Award; Dr Christine Williams, Chair of Life Sciences Queensland; Kelly McGrath recipient of Highly Commended honours in the LSQ Rural and Regional Service Award.

MEDAL OF *Agriculture 2021*

Professor Ian Godwin was awarded the 2021 Medal of Agriculture, presented by the Ag Institute of Australia.

Professor Ian Godwin leads research in the use of biotechnological tools for crop improvement (for food, feed, and bio-industrial end-uses) with emphasis on the sustainable production of grain crops. He has pioneered the use of GM and gene-edited techniques in sorghum.

He sits on the editorial panel for the prestigious journals, *Theoretical and Applied Genetics,* and *Frontiers in Plant Science*. He also regularly reviews papers for other journals including Plant Biotechnology Journal, Plant Physiology, Plant Cell Reports and Biotechnology for Biofuels.

HIGHLY CITED *researcher list*

Congratulations to Professor Ben Hayes, Director of the Centre for Animal Science, for once again making the global Highly Cited Researcher Awards for 2021, released by Clarivate. Honorary Professor Kemal Kazan also made the list. Congratulations to our UQ colleagues and collaborators who also made the list. See the full list of UQ's researchers on the 'HiCi' list this year.

The influential life of HENRIETTA MARRIE

Professor Henrietta Marrie's intellect, inner resolve and fight for fairness has taken her from the old Yarrabah mission near Cairns to the world, including several United Nations postings and Silicon Valley.

Now the eminent academic and Yindinji elder's extraordinary story is about to hit the big screen.

Professor Marrie, who chairs the First Nations Advisory group of the ARC Uniquely Australian Foods (UAF) Training Centre, based at QAAFI, will be the subject of a new biopic detailing her extensive and globally-renowned human rights work will be explored in the context of her fight to have her Great Grandfather's shell regalia returned to her family.

Ye-i-nie's adornments are currently housed in the British Museum in what Professor Marrie has described as evidence of institutionalised racism.

The documentary will be titled Bukal Bukal, Professor Marrie's language name.

From article by Renee Cluff, published in Topic Now, 4 June 2021

QAAFI's sorghum SUPERSTAR

Professor David Jordan's outstanding dedication to the Australian grains industry and the advancement of sorghum as a versatile and profitable crop has been recognised this year with his win of the Kondinin Group and ABC Rural 2020-21 Award for Excellence in Agricultural Research.

Hon David Littleproud, Minister for Agriculture, Drought and Emergency Management, presented the Award for Excellence in Agricultural Research to Professor Jordan in Canberra on 17 June 2021.

Professor Jordan's impact on the sorghum industry both within Australia and globally, through his leadership at the Hermitage Research Facility in Warwick, south-east Queensland, was recognised as outstanding. He has been key to productivity gains made by the Australian sorghum industry.

Underpinning this success is Professor Jordan's understanding of the needs of both the seed industry and growers and addressing these needs with integrated research—drawing on plant physiology, molecular biology and entomology.

"Sorghum is an amazing plant with genetic variation for almost any trait you can imagine," Professor Jordan said.

The 2020-21 Awards are supported by Platinum Sponsors WFI; Award Sponsors McDonald's Australia, AgriFutures Australia, Corteva Agriscience, Telstra and New Holland; Industry Supporters the National Farmers' Federation, AgSafe, Goldacres and Blundstone; Leadership Program supporter the Department of Agriculture and Water Resources; and Media Partner RM William's OUTback.

Advance Queensland FELLOWSHIPS 2021

Dr Anne Sawyer (mid-career) and Dr Chris O'Brien (early career) were successful in their bids for funding through the Advance Queensland Industry Research Fellowships (AQIRF) in 2021.

The Advance Queensland fellowships are open to Queensland-based PhD qualified early and mid-career researchers.

Early career Fellowships are worth $160,000 over two years, or $240,000 over three years and Mid-career Fellowships are worth $240,000 over two years, or $360,000 over three years.

UQ submitted 44 AQIRF 2021 applications, with nine awarded – two from QAAFI's Centre for Horticultural Science.

Dr Anne Sawyer

Dr Anne Sawyer is a joint appointment between QAAFI's Centre for Horticultural Science and UQ's School of Chemistry and Molecular Biosciences.

Dr Sawyer was successful in securing a total of $720,000 in funding over three years for her project *RNA vaccines for next generation crop protection: Facilitating adoption.*

Her work is developing biofungicides to combat pathogens that affect avocados, pineapple, and myrtle tree species.

Her industry partners include:

Department of Agriculture and Fisheries, Greenlife Industry Australia, Kai Loa Pty Ltd, NuFarm Australia Ltd, Pinata Farms, NQ Paradise Pines, Valley Ltd, Tropical Pines Pty Ltd, Howe Farming Enterprises Pty Ltd, Australian Native Products, ATTIA Ltd, New Zealand Forest Research Institute Limited, New England BioLabs Australia.

Dr Chris O'Brien

Following his research breakthroughs on the first critical steps to create a cryopreservation protocol for avocado, Dr O'Brien has secured $720,00 over three years from Advance Queensland, UQ and industry for his project: Innovating avocado for indoor cropping – Advance climate-smart production systems

Dr O'Brien received funding of $240,000 for three years for his project Innovating avocado for indoor cropping - *Advanced climate-smart production systems.*

His industry partners are:

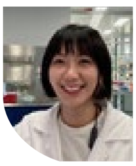
Costa Group, Department of Agriculture and Fisheries, Anderson Horticulture, The AvoTree Nursery.

3-minute thesis STARS

The 3MT (three-minute thesis) is a fantastic opportunity for students to share their research with the wider community and gain invaluable experience developing their presentation skills. Taking the form of a research communication competition, students must meet the challenge of effectively explaining their research in under three minutes to a non-specialist audience.

Our 2021 winners were:

Winner:



Wei-An Tsai
Centre for Horticultural Science

Plant-virus warfare: Can we help plants win the war?
Supervisor: Associate Professor Ralf Dietzgen
w.tsai@uq.edu.au

Runner-Up:

Christie Warburton
Centre for Animal Science

Breeding Designer Cows
Supervisor: Professor Ben Hayes
c.warburton@uq.edu.au

People's Choice:

Jane Ray
Centre for Horticultural Science

Going Bananas
Supervisor: Professor Andre Drenth
j.ray@uq.edu.au

60,000 years of **FARMING KNOWLEDGE**

QAAFI and DAF staff took part in a recent community workshop at the Hermitage Research Facility on 14 October, to plan an upcoming art installation that celebrates 60,000 years of farming knowledge.

The workshop was held to discuss the design for an art installation in preparation for the 125th anniversary of the Hermitage Research Facility in March 2022.

The art installation is part of an upgrade to the facility's visitor information hut, which will feature mosaics on sandstone blocks and two upright panels to tell the story of how traditional knowledge and agricultural research has contributed to the food security of our communities for the past 60,000 years and continue to keep us all fed well into the future.

The art installation is sponsored by a Regional Arts and Development Fund grant, QAAFI and DAF.

Southern Downs Regional Council residents, councillors, past and present Hermitage staff, and students from Scots PCG College attended the workshop.

Galibal Elder Aunty Kali, former Warwick Mayor Ron Bellingham, and Hermitage researchers Dr Emma Mace and Alan Cruickshank spoke about food production and the importance of gathering and preserving knowledge for food security.

Local Warwick artist Chris Hulme will incorporate information from the workshop into the design of the mosaic.

The final artwork will be unveiled on 20 April 2022 during the official 125th anniversary celebrations at Hermitage Research Facility.

SCOTS PGC College art students brainstorm design ideas during the workshop

Dr Barbara George-Jaeggli coordinated QAAFI support for the art installation and workshop

Finished cut out art on the wall

2021 *Simmons Trust Lecturer*

Professor Ala Tabor delivered the 2021 Simmons Trust Lecture at the annual meeting of the Australian Society for Microbiology (Queensland Branch). Her lecture, 'Tribulations and challenges with bovine genital campylobacteriosis research', covers 20 years of research by Professor Tabor and her team members.

The Simmons Trust Lecture is funded by the estate of the late Dr Geoffrey Clive Simmons. Dr Simmons spent his entire professional working career of nearly 40 years at the main veterinary diagnostic laboratory of the Queensland Government – the Animal Research Institute.

The Simmons Trust supports an annual Lecture that is given by an eminent veterinary microbiologist selected by the Trust – alternating annually between an international speaker and a national speaker.

Professor Tabor is just the third Queenslander to give the Lecture and joins a very esteemed group of researchers. The two previous Simmons Lecturers who were Queenslanders were the Nobel Laureate, Professor Peter Doherty, and UQ's Professor Paul Young.

Professor Tabor also shares another link with Geoffrey Simmons and Peter Doherty, as all three were based at the Animal Research Institute for at least part of their career.

QAAFI at BEEF WEEK 2021

QAAFI seminar presenters (L-R) Shannon Speight, Black Box Co; Russell Lethbridge, Werrington Cattle Company; Bim Struss, Agforce ; Hugh Killen, AACo; Prof Ben Hayes; Prof Mary Fletcher, A/Prof Luis Prada e Silva, A/Prof Heather Smyth. Panel MC facilitated by Jon Condon from Beef Central.

Beef 2021 takes place every three years in Rockhampton in May and is the biggest event on the beef calendar.

This year, a record crowd of 115,000 people attended, making the event not only the biggest Beef Week ever, but one of Australia's biggest events since the pandemic began.

Beef Australia celebrates all facets of the industry from paddock to plate. The event brings producers, scientists, chefs, students, exhibitors, business people and families together to enjoy the entire Beef 2021 event.

QAAFI hosted a stand in the exhibition area and hosted a sold-out Precision Beef Seminar on 5 May, which discussed improving breeding, feed efficiency, production, and beef flavours.

Dr Geoff Fordyce who retired in 2021 is acknowledged for his service

Precision Beef Seminar

Researchers presenting at the seminar included:

- Professor Ben Hayes, Director of QAAFI's Centre for Animal Science;
- Professor Luis Prada e Silva, a leader in the area of ruminant nutrition;
- Professor Mary Fletcher, a natural product organic chemist
- Associate Professor Heather Smyth, a flavour chemist and sensory scientist.

An Industry Panel of beef leaders included:

- Russell Lethbridge of the Werrington Cattle Company and MLA Board Director, who, with his family runs a commercial beef cattle, breeding, growing and fattening enterprise
- Bim Struss Agforce, Regional Director Southern Inland Queensland
- Shannon Speight Black Box Co, CEO
- Hugh Killen Australian Agricultural Company Ltd, CEO.

Emerging beef research leaders

A highlight was the three-minute presentations on their thesis topics by several of our PhD animal science students:

- Harrison Lamb - Crush-side genotyping to accelerate genetic gain livestock
- Melissa Wooderson - Achieving high standards of beef calf welfare in northern Australia
- Muhammad Kamran - Breeding for resistance to buffalo flies
- Emily Mantilla - Predicting tick resistance in cattle

We look forward to being part of Beef Week 2024.

Mr Aaron Wakley, A/Prof Heather Smyth and Chef Sam Burke at AACo's tent

QAAFI's trade display

Back row (L to R) – Ms Chian Teng Ong, Ms Tatiana Briody, Prof Bronwyn Fredericks, Dr Beth Woods, Ms Carolyn Martin
Front row (L to R) - A/Prof Heather Smyth, Dr Karen Eyre, Ms Melissa Wooderson, Ms Christie Warburton, Dr Karishma Mody

Peter Johnston, General Manager, Animal Science, DAF, at the QAAFI seminar

Prof Ala Tabor (left) and Prof Mary Fletcher (right) with Hon Mark Furner

SIMILESA: *Knowledge bridge carries hope and opportunity*

By Brad Collis

Daniel Rodriguez, a Professor of Agronomy and Farming Systems at QAAFI was leader of the Australian team of the Sustainable intensification of maize-legume systems for food security in eastern and southern Africa (SIMLESA) program.

Professor Daniel Rodriguez

For an agricultural scientist there is no greater challenge than to make a lasting impact on food and nutrition security across eastern and southern Africa.

This region is subject to an inconsistent climate and short crop cycles, compounded by low yields and prices which, year-in year-out, combine to create acute food shortages.

University of Queensland Professor of Agronomy and Farming Systems Daniel Rodriguez sees a glimmer of hope.

For nine years to the end of 2018, Professor Rodriguez was at the centre of an unprecedented global push to finally install a lasting foundation on which to build more resilient farming systems in this region.

He led the Australian contingent in the Sustainable Intensification of Maize-Legume Systems for Food Security in Eastern and Southern Africa (SIMLESA) program. This was a major global effort initiated by the International Maize and Wheat Improvement Center (CIMMYT) and funded by the Australian Centre for International Agricultural Research (ACIAR).

At the heart of the program, which began in 2010, was research and extension to guide smallholder farmers into conservation agriculture.

Based on the principles of stubble retention and minimum tillage, backed up with the breeding of more resilient maize and legume varieties and socioeconomic and market analyses, it drew heavily on QAAFI's expertise in tropical and subtropical agriculture systems.

The SIMLESA program, considered the most expansive agricultural development effort ever attempted in Africa, was spread across Ethiopia, Kenya, Tanzania, Malawi and Mozambique.

Early adopter farmers

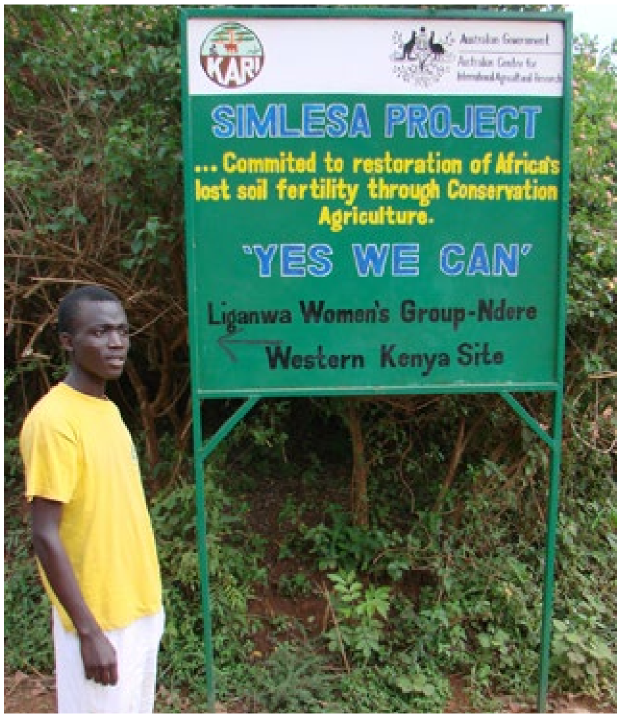
The foundations that were laid include an estimated 250,000 early-adopter farmers switching to this more durable farming system, the training of almost 300 African researchers and, crucially, the development of complementary government support policies.

The groundwork has been laid to improve the lives of tens of millions of the world's poorest people across Africa, and wherever in the world agricultural systems lag behind their achievable potential.

"It was the largest investment from Australia in Africa agriculture and the objective was to understand how to increase food and nutrition security through improved farming systems and practices and improved genetic materials," Professor Rodriguez said.

"The job is so enormous it is nowhere near done, but we have made a solid start that also benefits Australia. Because the regions are very similar environments to those in Queensland many of the learnings were just as valid across the two continents. Obviously, the socioeconomics are very different, but many of the production issues are similar."

Professor Rodriguez's team actually took Queensland farmers St John Kent and Paul Murphy, at the time CEO of seed company



SIMILESA project participant in Kenya

Radicle Seeds, to Africa to advise on ways to improve practices and seed systems: for example, how do farmers make sure they have access to seed of high quality and adapted varieties, at a reasonable price, at the time of sowing?

Global problems and solutions

The Australian presence also enabled access to CIMMYT's research on maize varieties resistant to fall armyworm. This is a pest of maize and sorghum crops that has only recently been discovered in Australia. Several resistant varieties are now being tested in Australia.

Professor Rodriguez says the primary SIMLESA objective was to help farmers adopt minimum tillage or no tillage to protect topsoil and retain soil moisture, supplemented by nitrogen-fixing legumes for forage and human consumption and improved plant genetics and market access.

Supporting this were professionals helping to build more effective value chains, market diversity and access, agribusiness opportunities and government and institutional support through improved policy frameworks.

With long-term impact a focus from the start, another major component of the SIMLESA program was to increase the agricultural science capacity of African institutions. This is also seen as key to attracting more support from international and national donors.

Mobile phone connectivity boosted uptake

Prof Rodriguez with farmer Grace in Malawi

"So it was a multidimensional and multidisciplinary effort involving large and diverse teams that even spoke different languages, working with the same objective of developing the research for development infrastructure needed to tackle such complex problems.

"Also because crops are mostly the responsibility of women there was a considerable social science component. For conservation cropping to be widely adopted the changes have to be led by women, so there were cultural and gender equity issues to work through."

Professor Rodriguez adds that most cultivation in these regions is done by hand or by using a draught animal. It does not alter the principles of minimum tillage and attendant weed-control challenges, but the practice could reduce women's workloads and free time for other economic activities such as producing cash crops for local markets.

The mobile connection

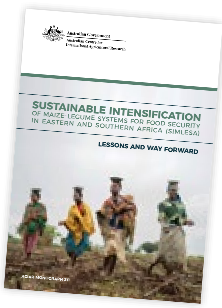
During the life of the SIMLESA program a parallel phenomenon was the rapid uptake of mobile phones across the community and farmers' willingness to use these to access information: "We rapidly developed SIMLESA's SMS delivery of agronomic, market and social networking information across the five countries."

By 2018, a survey of farmers reached by SIMLESA showed 64 per cent of women farmers (36 per cent of men) were receiving extension information via SMS. More significantly, 48 per cent of women and 51 per cent of men were acting on that information by making practice changes. This was the inception of digital agriculture in Africa.

"So, we were making a difference, having impact," says Professor Rodriguez. "That's what gives you reason to be proud … because that's our role; to have impact and create change. That's what the SIMLESA team achieved."

Professor Rodriguez says those who worked in the program have remained connected through the SIMLESA Legacy WhatsApp group: "Just waiting for the opportunity to do more."

Note: A recently published book chronicling the SIMLESA program, its lessons and the way forward is available from the ACIAR website: https://www.aciar.gov.au/publication/books-and-manuals



A book on the project, Sustainable intensification of maize-legume systems for food security in eastern and southern Africa (SIMLESA): Lessons and way forward, was released in May 2021.

SIMLESA science

ACHIEVEMENTS

- The production of high-quality evidence on the benefits and trade-offs of conservation agriculture for sustainable intensification. For example, out of 868 articles in Google Scholar citing SIMLESA, more than 100 were published in peer-reviewed journals, including articles in prestigious journals such as the Proceedings of the National Academy of Sciences, and Agricultural Systems.
- Increased science capacity in African institutions. For example, 65 masters and doctorate students studied in Australia, and African universities. This was in addition to non-degree training for 297 African researchers.
- Improvements in the infrastructure required to deliver quality science products by African institutions. This reflected in their capacity to attract new funding from international and national donors.
- Increased capacity of African institutions to influence the science policy in their own countries. For example, more than 60 policy briefs were published during the life of the project,
- Lasting networks of science have been created between African nations and Australia. And these networks continue to actively seek opportunities for funding, collaboration, and further work to help meet many of the Sustainable Development Goals.
- "SIMLESA was a flagship program that demonstrated to farmers, business people, policymakers and ministers, the promise and opportunity of conservation agriculture-based sustainable intensification.
- This book is a comprehensive and authoritative synthesis of selected results and lessons, reflecting the hard work and lessons learned by more than 60 African and 15 international and Australian scientists. The 26 chapters of this book build on the results of the SIMLESA program, identifying possible ways forward for sustainable intensification.
- This book will serve as a reference for those studying African agricultural science and food security. It will also be of interest to Australian and international scientists who wish to support the development of African farming and food systems."

Animal Science

Caption

Fertility is closely linked to profitability and can be substantially improved by new breeding methods based on cutting-edge genome technology.

Through the Northern Beef Genomics program, funded by Meat & Livestock Australia, UQ and DAF, and supported by beef producers and industry throughout northern Australia, we have analysed the DNA from 30,000 prime cattle. This pioneering genomics research is a key tool to transitioning to a low carbon future, and informs a suite of new DNA marker tools in proof-of-concept stage for delivery to industry.

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.

Research expertise:
Animal Welfare | Pests and diseases | Production systems

Drone image of cattle © QAAFI.

Optimum cattle management for precision beef

Professor Ben Hayes

The best way to value-add on the management of cattle herds across Australian environments is being brought into sharp focus by integrated research across the supply chain.

With the working title 'Precision Beef', the new program will pinpoint the value of new technologies that can maximise beef production and value.

The program is coordinated by Professor Ben Hayes, Director of the Centre for Animal Science at QAAFI.

He said it works by capturing and combining information about some of the key drivers of beef prices: genetics, rearing, environment, pasture, and a unique approach to meat quality.

"The key components of profitability in the beef industry are each technically complex research subjects," Professor Hayes said.

"What Precision Beef does is connect the dots, bringing together researchers that deal with different industry issues on one hand, and combining our understanding within one integrated computer system on the other.

Expertise in dealing with the key drivers of beef profitability exists within QAAFI and these researchers are well versed in working cooperatively and collaboratively.

They understand that each component works in tandem in the real world and their ultimate goal is to make gains that help farmers.

Professor Hayes says it all starts with the end consumer and an understanding of what makes for a pleasurable sensory experience when it comes to eating a beef product.

Taste analysis is becoming exceptionally sophisticated and has the ability to create profiles of the combination of fat, muscle fibre and assorted compounds that elevates beef to different price points. This is an area of research headed by sensory scientist Associate Professor Heather Smyth, and provides Precision Beef with quantitative measures of beef quality.

Computer algorithms will then make it possible to backtrack the quality data against how cows were reared, their genetics, the nutritional value of pastures, the associated methane production and even stress levels experienced by herds.

Each of these additional components are the subject of intensive research programs at QAAFI that use advanced technology including artificial intelligence and genomics.

An important focus of this work is the ability to select the genetics and pastures that can enhance reproductive efficiency and increase the number of calves a cow can produce over a lifetime. This has important efficiency and sustainability impacts.

Professor Hayes has developed a breeding program to select for improved fertility genetics, which is already improving the reproductive efficiency of 54 participating cattle herds.

Associate Professor Luis Prada e Silva

Concurrently, colleague Associate Professor Luis Prada e Silva can measure the impact on fertility of the nutritional value of different pastures, based on nitrogen levels in tail hair samples. Satellite images then could make it possible to survey the nutritional quality (and, therefore, its impact on fertility) of pastures across Australian landscapes.

The next step is to link back to the taste and sensory perception data to generate additional predictions on the quality and market value of beef products coming through the supply chain.

"The power of Precision Beef would come from combining datasets in such a way that producers gain clarity about the risks, costs and returns associated with different strategies for managing and marketing their cattle herds," Professor Hayes says.

"Producers could then opt to improve pastures and genetics with specific goals around the quantity, quality and value of beef they are producing."

The team presented a seminar on Precision Beef at Beef 2021 in Rockhampton to producers and industry representatives.

Calf drinking milk. Stock image.

Improving milk delivery and calf survival

Calf mortality is a key issue for the north Australian beef industry.

While selection for genetic traits to improve fertility will contribute to overall herd improvement, calf survival and future performance is heavily dependent upon management strategies producers employ in the breeding herd.

According to QAAFI's Associate Professor Luis Prada e Silva, poor nutrition and environmental stress are among the dominant factors impacting calf mortality.

"The cows need good nutrition during the last three months of gestation, especially protein, to sustain the growing foetus and prepare for lactation," Dr Prada e Silva said.

"However, in northern Australia, this period coincides with the end of the dry season, with poor-quality pastures available to feed the cows."

Research by Dr Prada e Silva with Brahman and Droughtmaster cattle identified that the lack of protein during late gestation had a major impact on calf survival.

"Both the lack of protein and heat stress will reduce milk delivery to newborn calves, decreasing the chance of survival and the future performance of the calf," Dr Prada e Silva said.

"Dehydration will quickly kill a calf."

Research undertaken by QAAFI's recently retired Dr Geoff Fordyce with Brahman-cross calves identified that calves that did not suckle or obtain adequate milk per day were likely to die within four days – under moderate temperatures.

In hot conditions, the rate of dehydration is much greater, with calves likely to die within two days of birth.

Unlike humans, calves are born without any protection against pathogens and must drink at least 3L of colostrum in the first 12h after birth to have a good chance of survival.

"We have identified the mechanism by which poor nutrition is affecting colostrum secretion and we are working with cattle producers to improve milk delivery to the baby calves," said Dr Prada e Silva.

Big data, fertility, and calf survival

'Precision Beef' is an integrated research strategy that pinpoints ways to maximise beef production and value.

The program is coordinated by Professor Ben Hayes, Director of QAAFI's Centre for Animal Science.

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Computer algorithms make it possible to backtrack the quality data against how cows were reared, their genetics, the nutritional value of pastures, the associated methane production and even stress levels experienced by herds.

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"The power of Precision Beef would come from combining datasets in such a way that producers gain clarity about the risks, costs and returns associated with different strategies for managing and marketing their cattle herds," Professor Hayes said.

These calf mortality research approaches form a program of work at QAAFI that supports the Northern Breeding Business (NB2) program, an initiative developed by Meat & Livestock Australia to address calf loss in northern breeding herds, low profitability of many northern beef enterprises, and low adoption of proven management practices and technology.

Improving farm animal welfare – what's it worth?

Many livestock companies are aware that Australians have growing concerns over the welfare of animals.

But it costs money to improve the welfare of farm animals – often a substantial investment by the business. There are many financial, practical, and ethical factors for businesses to consider when improving animal welfare, and the optimal course of action is not always obvious.

An article published in the Agriculture journal in 2021 seeks to address this dilemma facing businesses and farmers. The article, titled 'Costs and Benefits of Improving Farm Animal Welfare', written by animal welfare scientists in a collaboration between the Animal Welfare Science Centre and The Animal Welfare Collaborative at The University of Queensland, carefully weighs the costs and benefits of improving and not improving farm animal welfare, with a particular focus on the Australian livestock sector.

The article also provides an easy-to-use decision tool to support people with farm animals under their care to make evidence-based decisions about changes in practice to improve animal welfare.

Many of the costs are obvious. For example, training of stock people, reconfiguration of pens, and administration of pain relief can improve farm animal welfare, but all of these come with costs.

On the other hand, the costs of not improving animal welfare may be less obvious but are just as significant. For instance, businesses may run the risk of losing a portion of their customers to higher welfare products, they may be shut out of certain international markets almost overnight, they may be forced to implement costly changes with the introduction of new legislation, or they may gradually lose their social licence to farm by not ensuring good animal welfare.

The benefits of improving farm animal welfare are also difficult to evaluate from a purely economic perspective. Most farmers acknowledge that animals with poor welfare are unlikely to produce at optimal levels, but there may be other benefits of improving farm animal welfare that extend beyond production gains. These include benefits to the animal, positive effects on the workforce, competitive advantage for businesses, mitigation of risk, and positive social consequences.

The article weighs these considerations and integrates them into a decision tool that can assist people with farm animals under their care, and the authors highlight the need for further empirical evidence to improve decision-making in animal welfare.

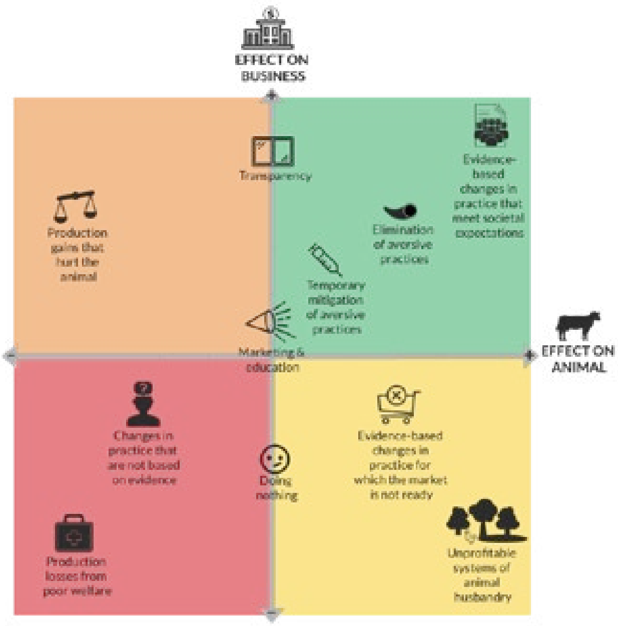


Figure copied with permission from Fernandes, J.N.; Hemsworth, P.H.; Coleman, G.J.; Tilbrook, A.J. Costs and Benefits of Improving Farm Animal Welfare. Agriculture 2021, 11, 104.

New portable ‘DNA clock’ measures age of cattle

A portable DNA sequencer has been successfully used to estimate the age of cattle, an innovation that is a game changer for the northern cattle industry.

“The core issue facing the northern beef industry in Australia is an inability to determine the age of individual animals,” said Professor Ben Hayes, Director of the Centre for Animal Science at The University of Queensland.

“In northern Australia, herds range freely in between annual musters and the date of birth of individual animals are generally not recorded.

“Without age records, it’s difficult to establish the baseline growth rates, age at puberty and inter-calf intervals of individual animals.

This makes it very difficult to apply genomic predictions, and there’s also an adverse impact on herd management.”

With funding from Meat & Livestock Australia and support from the Department of Agriculture and Fisheries in Queensland and beef producers across northern Australia, UQ researchers have developed a new use for the MinION portable, real-time DNA sequencing device - as an ‘epigenetic clock’, to read the age of an animal from the DNA extracted from its tail hair.

Michael Crowley, General Manager Research Development & Adoption at Meat & Livestock Australia said being able to use the methylation of DNA to estimate an animals age was an exciting development towards unlocking the value of a variety of datasets.

“MLA supported this work because we have seen the benefit that genomics can bring to the red meat industry,” Mr Crowley said.

“Ideally, using this “DNA clock” means that the performance data and DNA gathered from cattle will be used as a reference population that enables genomic predictions. This would complete the feedback loop and make sure that this industry data could be used to drive ongoing genetic improvement.”

The work is led by UQ Research Fellow Dr Elizabeth Ross, who said UQ’s MinION device can deliver genomic DNA sequence typically extracted from tail hairs from cattle to a laptop in timeframes as low as one hour. Her colleague, Dr Loan Nguyen, led the sequencing efforts, developing protocols that will be used in several new studies that aim to benefit Australia’s beef industry.

MinION is unique in that it not only sequences the genome but produces a second set of data based on translating chemical modifications – called methylation – made to the DNA molecule.

“In effect, this gives us the genetics plus an indication of what is happening with the animal now – a reading of the influences management and environment have on its genes,” Dr Ross said.

“Cells methylate certain DNA regions to create patterns that vary in different tissues and MinION can read these patterns.”

Importantly for the cattle industry, the methylation patterns are known to change with the age of an animal.

“Specifically, methylation increases with age in some specific spots of the genome and decreases in others” Dr Ross said.

“By detecting methylated DNA, MinION can be used to estimate the age of an animal. The method works across all ages in a herd – from five days to 14 years.”

The new method accurately measures cattle age to within 1.5 years.

“The method has only been calibrated with a relatively small sample size of animals with known ages, so the estimates will tighten as the sample size increases,” Dr Ross said.

“That’s the development bottleneck; we have thousands of tail samples, but too few from animals with known dates of birth.”

The UQ researchers are now working to include hundreds more tail hair samples before taking the technology for proof-of-concept trials on cattle stations in 2022.

If adopted by producers, the technology can deliver both the age estimate and genomic predictions from the same DNA test.

It’s an innovation with important implications for rapidly improving herd performance.

Dr Ross expects gains to all sorts of traits – anything with a genomic component. That includes fertility, growth rates, health, and meat traits.

“Technology is moving quickly in this space,” Dr Ross said.

https://doi.org/10.3389/fgene.2021.760450

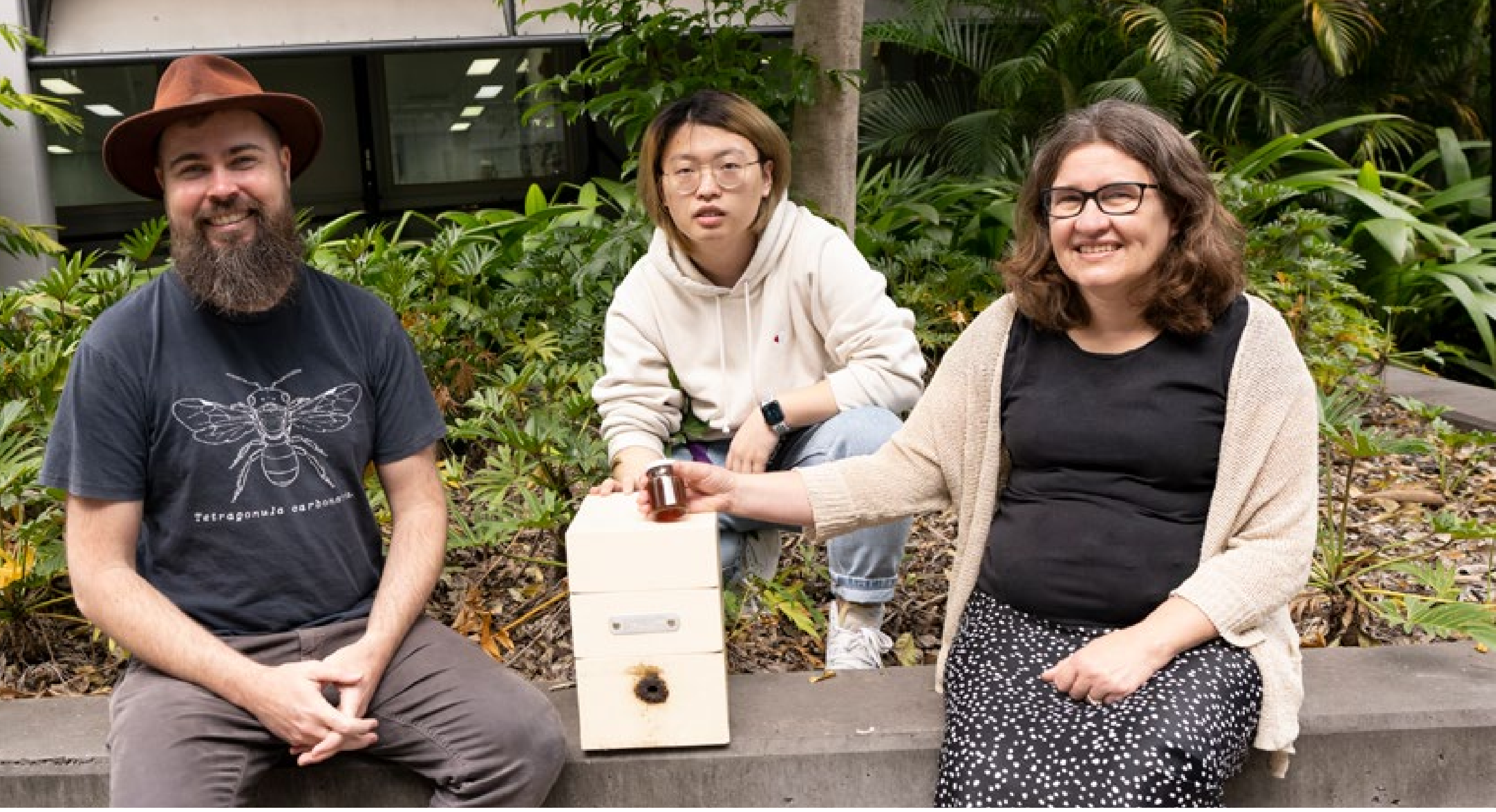
How MinION works as an epigenetic clock

MinION technology is portable and fast; it also reads DNA sequence in a novel way.

The device passes DNA through pores in a membrane (called a flow cell). As the DNA passes, it disrupts the flow of ions. This electrical disruption occurs slightly differently for each of the four letters in the genetic code, which complex computer algorithms can then use to work out the sequence of the DNA.

Additionally, the flow of ions is also differently disrupted if the passing DNA contains chemical modification in the form of methyl tags on the DNA. This allows the device to detect and report on the methylation status of the sequenced DNA.

Traditional DNA sequencers that are used to read entire genomes are unable to ‘see’ whether or not the DNA is methylated as it uses a chemical approach to decipher the sequence.



Dr Natasha Hungerford with her collaborators Jiali Zhang (QAAFI PhD student) and Dr Tobias Smith a bee researcher in UQ School of Biological Sciences. Photo credit: Jiali Zhang 2021

Healthy sugar origin in stingless bee honey revealed

The mystery of what creates the rare, healthy sugar found in stingless bee honey, has been solved by researchers at The University of Queensland, in collaboration with Queensland Health Forensic and Scientific Services.

The team found that the sugar trehalulose – which is not found in other honey or as a major component in other food – is produced in the gut of the bees.

UQ organic chemist and research leader, Dr Natasha Hungerford said the origin of this rare sugar had been a puzzle since the discovery of high levels of sugar trehalulose in stingless bee honey.

"We did not know if the trehalulose was coming from an external source – perhaps from native flora," Dr Hungerford said.

"It could have been something in the resin from trees that stingless bees collect and take home to their nest - because unlike European honey bees, which store their honey in honeycomb made only from beeswax, stingless bees store their honey in small pots made from a mix of beeswax and tree resins."

Stingless bees are found throughout tropical and subtropical parts of the world.

The larger, European honey bees (*Apis mellifera*) produce significantly more honey, and are the world's major honey production species.

However, stingless bee honey which is highly prized as a specialty food, is noted in Indigenous cultures for its medicinal properties and attracts a high price.

"Trehalulose is more slowly digested and there is not the sudden spike in blood glucose that you get from other sugars," Dr Hungerford said.

She said the UQ team was keen to determine if the trehalulose content in stingless bee honey could be increased, potentially making stingless bee honey more valuable.

"We fed confined colonies of the Australian stingless bee *Tetragonula carbonaria* the most common sugars found in flower nectar - sucrose, glucose and fructose.

"What we found is that stingless bees have a unique capacity to convert sucrose to trehalulose and produce honey rich in trehalulose in their gut."

Native plants such as Grevillea and Banksia are believed to have nectar high in sucrose, and it is believed bees feeding from these plants will naturally produce honey rich in trehalulose.

The team also found that stingless bees fed a solution containing table sugar could convert it into a 'honey' containing high levels of trehalulose.

"But the 'honey' they produce from table sugar does not meet the requirements of real stingless bee honey which is made from nectar," Dr Hungerford said.

"The honey we produced in the lab is in fact fake honey, and we were able to distinguish it from natural honey by isotopic testing.

"This trehalulose-rich syrup that was produced might be considered a potential secondary product of stingless bees, but it is not honey.

"It is also not good for the health of the hive to feed the bees only table sugar.

"Honey contains a complex range of phytochemicals from nectar, making it vitally important for brood rearing and the expansion of the colony population."

The UQ team will now work to identify different horticultural crops that have nectar high in sucrose.

"We want to investigate the nectar sugars present in crops such as macadamia, lychee and avocado, and whether stingless bee pollination of these crops could result in a high level of trehalulose in their honey," Dr Hungerford said.

The research was funded by AgriFutures Australia, Queensland Health, Department of Agriculture and Fisheries and the Australian Native Bee Association.

Dr Lida Omaleki

Chickens outdoors in a free range layer farm
© Lida Omaleki

Henrietta at home in her nesting box

Shape-changing bacteria evade fowl cholera vaccines

The access to open air and outdoor lifestyle that is a feature of free-range chicken farming may well be putting birds at a higher risk of an untimely death.

Researchers have long understood that despite their more socially acceptable existence, free-range chickens are exposed to more disease agents when compared to caged chickens.

Now, new research has established that *Pasteurella multocida*, the bacterium that causes fowl cholera, is intuitive enough to switch on and off certain genes to outsmart vaccines, leaving free-range chicken flocks exposed to the often-devastating effects of the disease.

The finding from UQ's Dr Lida Omaleki, based at the University of Queensland (UQ), also points to the need for whole-genome sequencing to help chicken producers identify changes in bacterial strains and better protect their flocks.

The death of chickens is often the first sign that a flock is infected. Chronic symptoms can include fever, loss of appetite, respiratory difficulties and a bluish discolouration of a bird's skin, wattle and comb. Stresses, such as fox or dingo attacks, can also lower immunity levels, exposing the chicken to greater chance of infection. The responsible bacteria, *P. multocida,* can also be carried and transferred to chickens from foxes, rodents and migrating birds.

Production levels in flocks for both meat and eggs are impacted after an infection of fowl cholera, which is less prevalent in chicken flocks held inside sheds because of the closely controlled environments and closer monitoring of animal health.

Dr Lida Omaleki's research at UQ is part of a QAAFI project co-funded by Australian Eggs and AgriFutures Chicken Meat Program. Using genomic analysis, she has discovered why some vaccines were not proving effective against fowl cholera.

The most widely used form of vaccine to combat fowl cholera is a 'killed vaccine'. Live bacteria are taken from the carcasses of an infected flock, grown in the laboratory and then killed, providing the basis for a vaccine to protect subsequent flocks on the same property.

Dr Omaleki says the killed bacteria used in the vaccines for each farm should have the exact outer structure as the strain that produced the disease on that farm.

However, genomic analysis has illustrated the ability of the bacterium to evade vaccine induced immunity by changing the outer surface structure, including by switching genes on and off.

The research shows that traditional bacterial analysis techniques are not specific enough to identify genetic variations in bacteria strains. Future analysis must use whole-genome sequencing to understand how *P. multocida* responds to vaccine pressure.

"There is an urgent need in the industry for genomic-based analysis techniques so we can sequence the whole genome of each bacterium, and from there we will have a better way of predicting these changes to the outer structure of the cell," Dr Omaleki says.

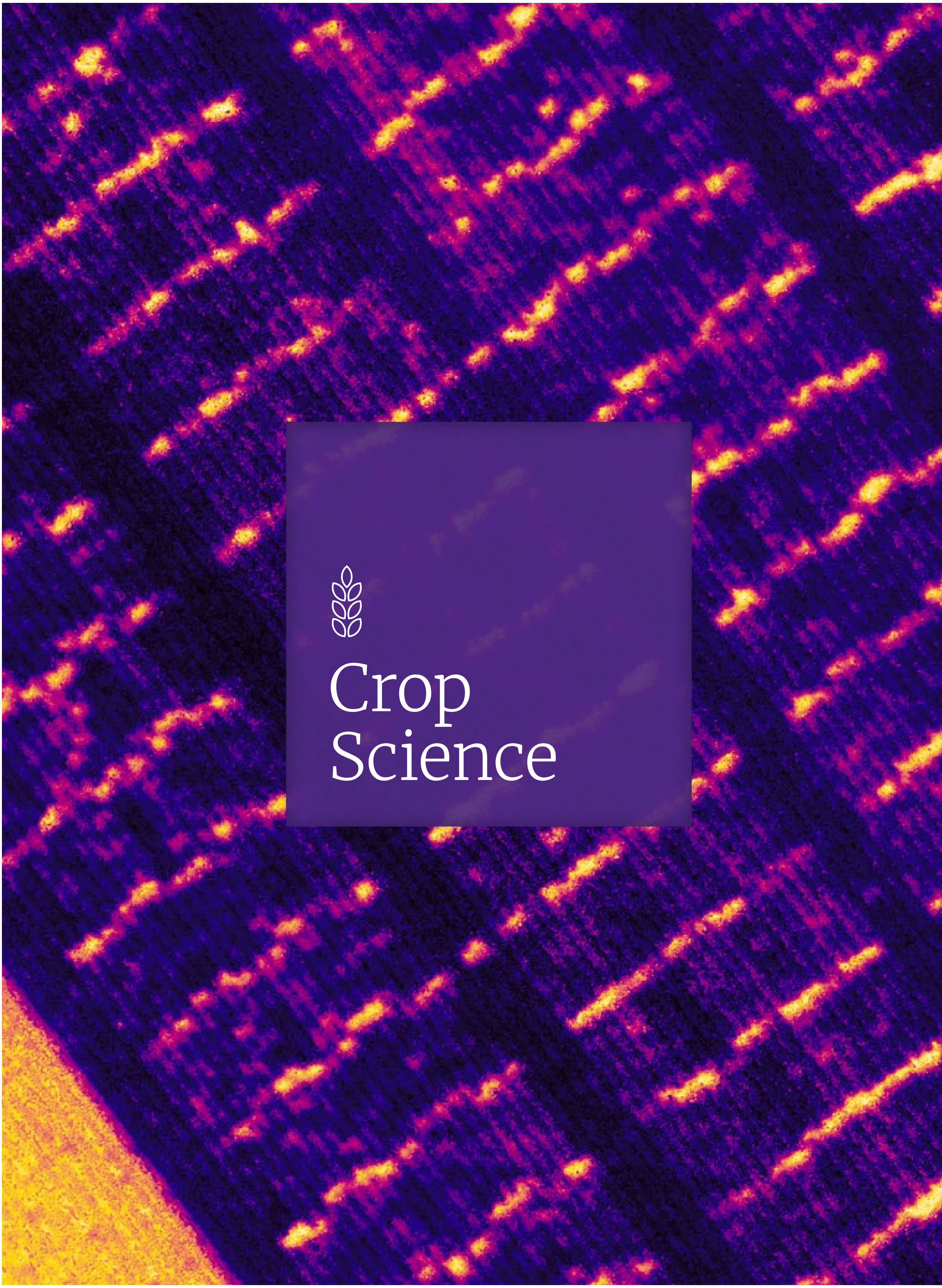
"If we can understand the specific strains in certain flocks, we will be able to better guide vaccination programs as well as identifying where the strains are coming from, and perhaps introduce improved biosecurity practices to protect the chicken flocks."

The findings from this three-year national project will allow Dr Omaleki and the research team at QAAFI to investigate ways to overcome this adaptive ability of *P. multocida*, a mechanism that the bacterium uses to undermine the effectiveness of vaccines.

A related pathogen, which causes middle ear infections in humans, has also been identified as having the ability to switch genes on and off, resulting in a change in bacterial outer structure.

Dr Omaleki's research findings have demonstrated the potential of a similar mechanism in *P. multocida* for the first time.

Crop Science



We are global leaders in research targeting enhanced profitability and sustainability of cereal and legume cropping systems in tropical and sub-tropical environments.

We integrate molecular, whole plant, and system level production science in crop genetics, physiology, and modelling, 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.

Our research expertise:

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

Our DAF colleague Kenneth Laws is QAAFI's 'eye-in-the-sky' for many crop phenotyping projects based at the Queensland Government's century-old Hermitage Research Facility in Warwick.

This image, supplied by Ken, is a thermal map of a sorghum yield trial showing canopy temperature differences: "Monitoring changes in canopy temperature from UAV imagery can be used to determine stomatal conductance in large numbers of genotypes rapidly," Ken said.

"This enables us to screen for drought adaptation and water use efficiency. The ability to measure traits like this, through the whole life cycle of a crop, is a step-change for crop improvement".

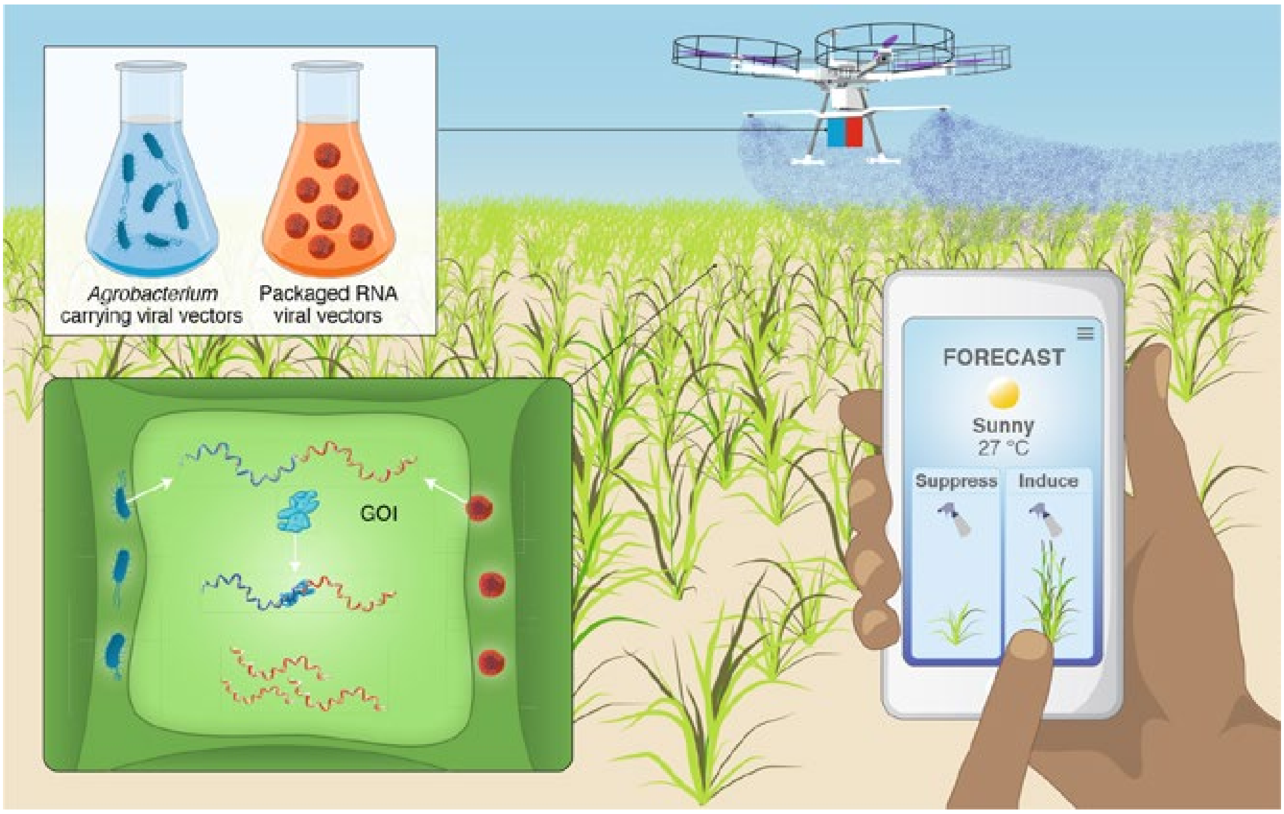


Image courtesy of Ella Maru Studio.

Spray on genetics to fine-tune crop growth

'Tunable' crops, able to respond to real-time environmental scenarios by fine-tuning their genetics, are just a spray away, University of Queensland researchers say.

Dr Karen Massel

Genetic control of crop growth and behaviour can be modified through traditional breeding programs or through genetic engineering but, in both cases, genetic control is fixed once a variety is sown.

Now with advances in gene-editing and breakthrough new international spray-on viral transfection technology, the fine-tuning of genetics relating to crop growth can now be done with a spray that rapidly alters gene expression in the crop while avoiding modifications to the genome.

"The aim is for the grower to have the ability to alter gene expression in order to fine-tune agronomic traits during the growing season," said QAAFI's Dr Karen Massel, who along with her colleagues Associate Professor Lee Hickey and Professor Ian Godwin, published a news article in Nature Plants on February 2021 on tunable crops.

"We were inspired by the work of Torti and others on the transient reprogramming of crop plants for agronomic performance.

"This new technology takes gene editing out of the lab and into the field. It is a rapid, real-time solution to environmental challenges.

"Obviously, one of the greatest concerns with any new technology is the impact it may have on the environment and consumers, and we really need more research on this."

How it works:

Transient spray-on viral technology is applied to improve crop performance in response to real-time environmental conditions. Agronomic traits can be fine-tuned through transient viral induction delivered to the crop through an aerial spray application. The RNA viral replicon technology can be delivered to the plant cell as DNA via transient Agrobacterium transformation or packaged into RNA viral particles to eliminate DNA release into the environment. Within the plant cell, the deconstructed RNA viral vector components (blue) contain a movement protein and a viral RNA-dependent RNA polymerase (RdRp) to amplify the desired gene of interest (red), systemically inducing its expression to transiently manipulate the target traits according to the needs. For instance, as depicted above, early flowering is induced to minimize yield losses when the forecast predicts a dry season. However, if the forecast predicts precipitation, flowering could be suppressed to maximize yield potential. GOI, gene of interest.

Managing key genes on the farm

For crop production, the technology could provide a new management tool to tune agronomic performance post hoc.

Depending on local weather conditions, key genes in developmental pathways could be selectively reprogrammed. For example, if no rainfall is predicted for an early sown crop of wheat, the expression of *FLOWERING LOCUS T (FT)* could be manipulated to induce early flowering and avoid drought stress.

Plant developmental genes are obvious targets for spray-on transient technology; however, these 'master regulators' often have pleiotropic effects on multiple traits. For instance, by limiting the response to the growth-promoting hormone gibberellin, the Green Revolution dwarfing gene Rht-1 confers short stature to reduce lodging, but also reduces early vigour and weed competitiveness.

If transient spray technology can be deployed at an industrial scale, it could circumvent pleiotropic developmental genes and enable new trait combinations for optimal crop performance within the season.

Read more in Massel, K., Godwin, I. & Hickey, L. Tunable crops are just a spray away. *Nat. Plants* 7, 102–103 (2021).

Image: QAAFI

Boosting barley production, from the ground up

Researchers are taking to the skies to help see what is happening underground in a new project that aims to improve one of Australia's largest grain crops - barley.

University of Queensland's Associate Professor Lee Hickey is leading a study investigating ways to optimise root systems and help barley growers improve yield stability, particularly in the dry seasons.

"For a century, plant breeders have focused on what happens above the ground in terms of adapting crops to diverse production environments," Dr Hickey said.

"Barley breeders have traditionally focused on breeding for traits that are visible such as plant height and flowering time.

"Over the years, important root traits could have been inadvertently selected, but there may be a lot more we can achieve."

The project will employ cutting-edge technologies to fast-track barley breeding for diverse production environments in Western Australia, Victoria, South Australia, New South Wales and Queensland.

The research team will make use of advances in remote sensing technology such as drones fitted with multispectral cameras.

"With the new sensors we can fly drones across field experiments to measure traits the eye can't see like canopy temperature, and this can tell us a lot about how much water the crop is using," Dr Hickey said.

The team will match this data with soil coring samples taken in the field, to better understand the relationship between canopy traits and root traits.

"Understanding the value of different root traits is key," he said.

"On farms with deep soils that rely on stored soil moisture, a deeper root system could improve access to moisture in dry seasons.

"However, more vigorous root growth in the upper soil layers could be advantageous for crops grown on shallow soils that rely on rainfall during the growing season."

Another tool is CRISPR genome-editing technology, which could assist researchers in engineering novel genetic variation by targeting key genes that influence root system development.

"If we can successfully harness the new technologies to improve root systems in barley, this approach could also be used in breeding programs for other major cereals such as wheat and oats," Dr Hickey said.

The 'Digging deeper to improve yield stability' project is in partnership with InterGrain and the Australian National University and funded by an Australian Research Council Linkage grant.

InterGrain barley breeder Dr Hannah Robinson said a big part of the research would focus on creating an "optimum root shape" for varying soil profiles across Australia, tailoring barley root systems to be better adapted to Australia's diverse environment and production systems.

"This should improve water and nutrient extraction, and thus ultimately yield, in the variable and changing climates we now face in Australia," Dr Robinson said.

"It is about validating what is the best for each unique soil profile and environment, then breeding varieties with optimised root systems adapted to those environments across Australia."

Barley is the second largest grain crop in Australia with the industry valued at $3 billion per year.

Associate Professor Lee Hickey and Dr Hannah Robinson.

The secret to sorghum's adaptability

Queensland scientists have developed the world's first pan-genome for sorghum in a breakthrough for crop improvement and gene discovery.

The landmark research provides unprecedented insights into the genes that makes sorghum such a hardy and resilient crop.

Minister for Agricultural Industry Development and Fisheries Mark Furner said the discovery unlocks the genomic treasures to breed improved varieties of the ancient cereal grain.

In Queensland, sorghum is a staple crop, used mostly in the intensive livestock sector and was worth more than $250 million in 2021.

A reservoir of genes that allowed sorghum to adapt to different environmental and disease stresses during domestication and cultivation has been identified from an analysis of 13 contrasting sorghum genomes.

The genes' role in overcoming adverse growing conditions makes them especially valuable to breeders. Already, the new data is helping to improve yield and yield resilience of cropped varieties in Australia that face mounting production challenges, including from climate change and increased water scarcity.

The breakthrough is the result of a partnership between Australian and Chinese researchers led by QAAFI's Dr Emma Mace, together with Dr Yongfu Tao and Professor David Jordan, who heads a world-leading sorghum pre-breeding program.

Dr Mace said the ability to see this important class of 'adaptation genes' is a direct result of opting to analyse lines that span sorghum's domestication history. The selected genomes were then sequenced in their entirety and compared using advanced computational methods.

"We wanted to be sure that the DNA sequencing data captured the key events that shaped the genome during domestication and subsequent cultivation," Dr Mace said.

To that end, the 13 lines selected for sequencing included five wild relatives of cultivated sorghum, including an Australian native. All five species can be crossed to cultivated sorghum, allowing valuable genetic diversity to be readily transferred to breeding lines.

The remaining lines span four 'racial groups' of cultivated sorghum, with the groups representing adaptations to different growing conditions. Included are lines from Australia, Africa, Philippines and northern China.

Of the findings, Dr Tao says that the average genome was found to contain 31,000 to 36,000 genes. However, only about 70 per cent of genes are similar across all 13 genomes. These are called the 'core' genes. The remainder are drawn from a larger pool of 'dispensable' genes that vary dramatically across genomes.

"The data indicates that sorghum acquired and disposed of genes on a large scale as a result of adapting to different growing conditions," Dr Tao said.

Flowering sorghum growing in trials at the Hermitage Research Facility in Warwick.

Dr Emma Mace with sorghum seed collection at Warwick.

"Of the 44,079 gene families we catalogued from the totality of the data, 64 per cent of families include dispensable variants."

As expected, the greatest number of unique genes was detected in the wild relatives of sorghum. However, each racial group was found to contain something novel to offer breeders. This is the genetic diversity that is strongly associated with adaptations to biotic and abiotic stresses.

"What really came across strongly from this project is that plant genomes are more dynamic than previously imagined," Dr Mace said.

"There has been a recent evolution in thinking, away from the concept of a single reference genome per species. We now realise more valuable information is available by comparing genomes, in other words, with a 'pan-genome approach'."

She adds that this shift is possible due to advances in DNA sequencing technology realised during the past decade, including dramatic drops in the cost and time needed to sequence the vast amount of DNA in a genome.

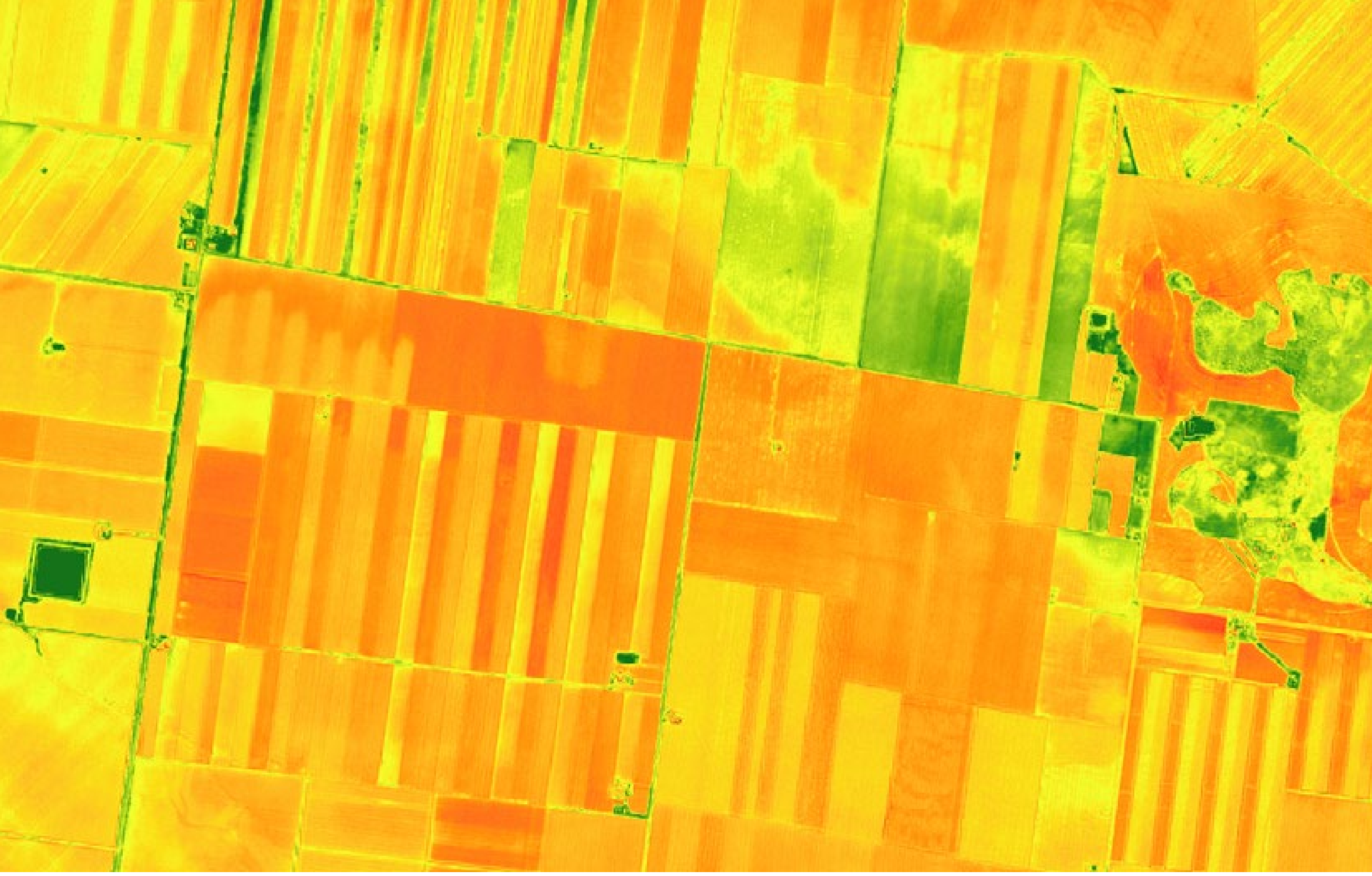
Importantly, the researchers also have access to information about how the 13 selected lines perform in the paddock. That means the genetic data has correlations with trait differences, such as head shape, flowering time and grain colour.

Overall, the team believes that the new understanding creates opportunities to use genetic diversity in a new, more profound way. Rather than exploiting an individual gene variant here and there within a breeding program, the team envisions scenarios where complementary sets of genes associated with particular adaptations are exploited to drive up the hybrid vigour of cultivated varieties.

"Our approach was always practical, with the project designed to have applications in breeding that help drive gains in productivity for the grains industry," Professor Jordan said.

Also taking part in this project is the Department of Agriculture and Fisheries in Queensland, the Chinese Academy of Sciences and BGI Genomics in Shenzhen, China.

The project was funded by the Global Crop Diversity Trust and the Australian Research Council. The findings were published in *Nature Plants*, 20 May 2021, in a paper entitled 'Extensive variation within the pan-genome of cultivated and wild sorghum'.



Modelling climate variability to drive crop outcomes

By Jill Griffiths

Professor Graeme Hammer was involved in the establishment of the Agricultural Production Systems sIMulator (APSIM), a comprehensive model developed to simulate biophysical processes in agricultural systems. He aims to deliver robust crop models to predict likely outcomes and production risks via simulation with climatic scenarios.

Professor Graeme Hammer

In an increasingly variable climate, getting the right information to guide management decisions on farm becomes ever more critical and ever more complex.

"Crop growth and yield are determined by a complex interaction between genes, management and the environment," said Professor Graeme Hammer, of The University of Queensland.

He said predicting the outcomes arising from variations in many interacting factors is one role of models that researchers use to formulate advice.

"Climatic variability in dryland production environments generates crop production risks. Every year is different and even less predictable with anthropogenic global warming.

"Optimal combinations of genotype and management thus vary among sites and seasons."

Professor Hammer said the possible outcomes of genotype and management options create a complex landscape of possibilities, with peaks and troughs.

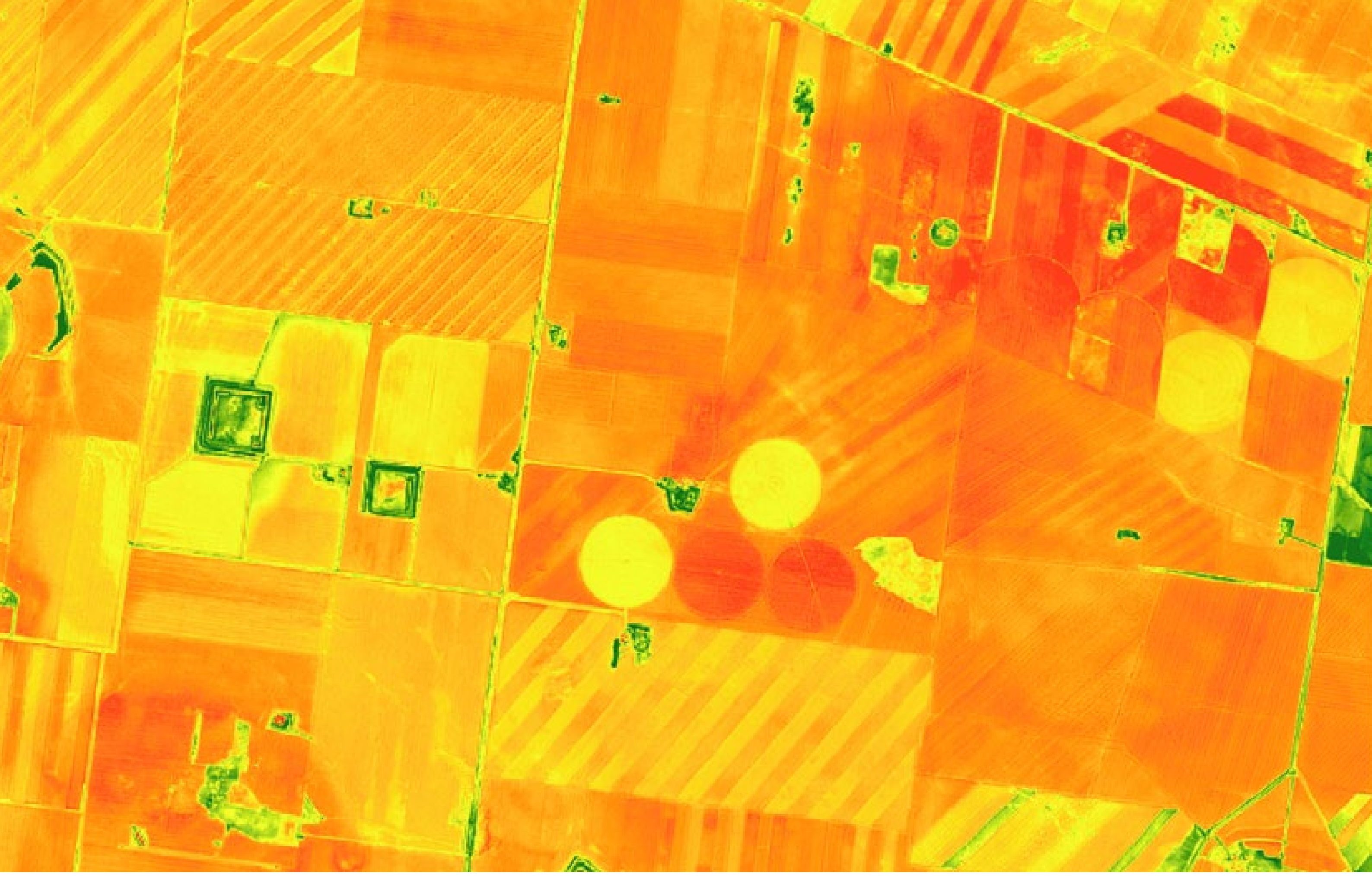
"We want to get to the peaks and avoid the troughs," he said. "But the peaks aren't stable. It's more like an ocean with waves. How do you predict where you are and navigate to where you want to be? Understanding that is a key part of improving crop production."

Modelling scenarios

Professor Hammer has spent over 30 years working on APSIM, the now internationally-used model that researchers use to understand and predict how crops will perform in certain situations. It's used to guide decisions about the genotypes that are selected for particular environments and situations, and to guide agronomic advice.

"Robust crop models provide an avenue to predict likely outcomes and production risks via simulation with climatic scenarios," Professor Hammer said.

"What might happen given particular combinations of genotype and management? The ultimate result is the yield that will be obtained, but there's a black box in the middle making it hard to predict. That's where the model sits.



Soil moisture pre-sowing map. Relative Soil moisture (scale: drier (red) to wetter (green) utilising the latest high-resolution imagery from Sentinel-2 captured on 14 May 2020 in Dalby, Australia. Image: CropVision project LP CropScience QAAFI

"There's a whole lot of data we can collect these days. We are drowned by bucketloads of it, or perhaps it's now by terabytes.

"You can genomically sequence a lot of plants. You can run UAVs over a lot of fields. But you've just got data. People get lost in the tech of getting the data and don't think enough about what to do with it. And now this has spurred the field of 'big data' and motivated the emergence of all sorts of analytical solutions – deep learning algorithms and so on. But what is lacking is biological insight to enhance effective scaling from genotype and management to phenotype. That's the black box in the middle that can enhance effective prediction.

"When we come back to the black box, we can put a crop model in to link genotype and management to outcome. The black box includes crop factors, climate factors, management factors, soils, light, temperature.

"It captures the dynamics that emerge from the tangled web of interactions and feedbacks, based around quantification of physiological determinants of crop growth and development. You can capture the biology into simple equations at different stages."

Climate variability is critical

Professor Hammer said that models require high quality data from across a wide range of conditions to enable robust predictions for different and diverse scenarios.

He used the example of sorghum from his own research where a 100-year simulation was run to look at specific situations. The modelling showed that a high intensity strategy (high plant density, high inputs) pays off in good years but a low intensity strategy is less risky, with fewer years below break-even.

"The only variable is seasonal weather," Professor Hammer said.

"To extend that simple example, what we have looked at, is doing that across the sorghum production region of Australia with a range of genetic and management factors. We found climatic variability is critical. Effective use of water is what it is all about, so the simulation is about estimating the yield-risk profile for crop decisions using historical data to reflect seasonal variability.

"If you look at the sort of adaptation landscape generated by such a comprehensive simulation study, it gives a number of different feasible outcomes, and the preferred choice really depends on the risk profile of the manager.

"Initially you can pick out genotype attributes that fit best the yield-risk profile across the whole region, much as would be done in a plant breeding program to identify broadly adapted material using standard agronomy. Then you can break it down by region and look at the preferred management for that region based on yield-risk outcomes – that's what an agronomist does. 'Here's my best genotype and here's how I adapt my management to it.'"

The novel finding in this study was that there is greater potential advance if both the genotype attributes and management factors are considered simultaneously. This requires new ways to work that are capable of integrating breeding and agronomy. Crop modelling opens that door.

"It's the integration that makes the difference," Professor Hammer said.

"It is important to think about where you are headed before you take off. We need to connect people up and have researchers understand the language of other disciplines and work closely with practitioners.

"Unless there is a change in decision-making by breeder, agronomist, or grower, then there is no impact."

Article published courtesy Farming Ahead/Kondinin Group. First published July 2021.

Future digital technologies for crops

By Rachel Shekar

Digital technologies can be used to mitigate and predict production losses with real-time data.

Associate Professor Andries Potgieter

Associate Professor Andries Potgieter leads and mentor a team of researchers in the areas of seasonal climate forecasting, remote and proximal sensing with applications in the development of crop production outlooks and less risk prone cropping systems across Australia.

Production decisions:

- When should I begin applying variable-rate fertilizer and where?
- Do my south fields have a pest or disease problem?
- Will planting delays due to heavy rains reduce regional crop yields? What about the hot and dry summer due to El Niño?
- Which fields need to be hayed-off due to crop stresses like frost, heat, or drought?

Digital technologies can be used for management intervention such as fertilization, pest control, stress detection, irrigation management, and weed control before they negatively impact crop productivity.

Accurate information on the spatial distribution and growth dynamics of cropping are essential for assessing potential risks to food security and are also critical for evaluating the market trends at regional, national, and even global levels.

QAAFI's Associate Professor Andries Potgieter is the lead author of a new paper published in in silico Plants that reviews what's new and what's next in the world of digital technologies for crops.

He said: "This paper, highlights the advances made in earth observation, machine learning and cloud computing technologies, specifically during the last 5-years.

"It furthermore, discusses the fusion of such technologies with targeted knowledge-based biophysical systems which will lead to more cutting-edge applications within agriculture. Such integrated predictive physical systems have the potential to mitigate the impact of climate extremes and change on agricultural production systems.

"Specifically, in Australia where the projected impacts of future climates on food production is of more concern tom the sustainability and resilience of industries to cope with it."

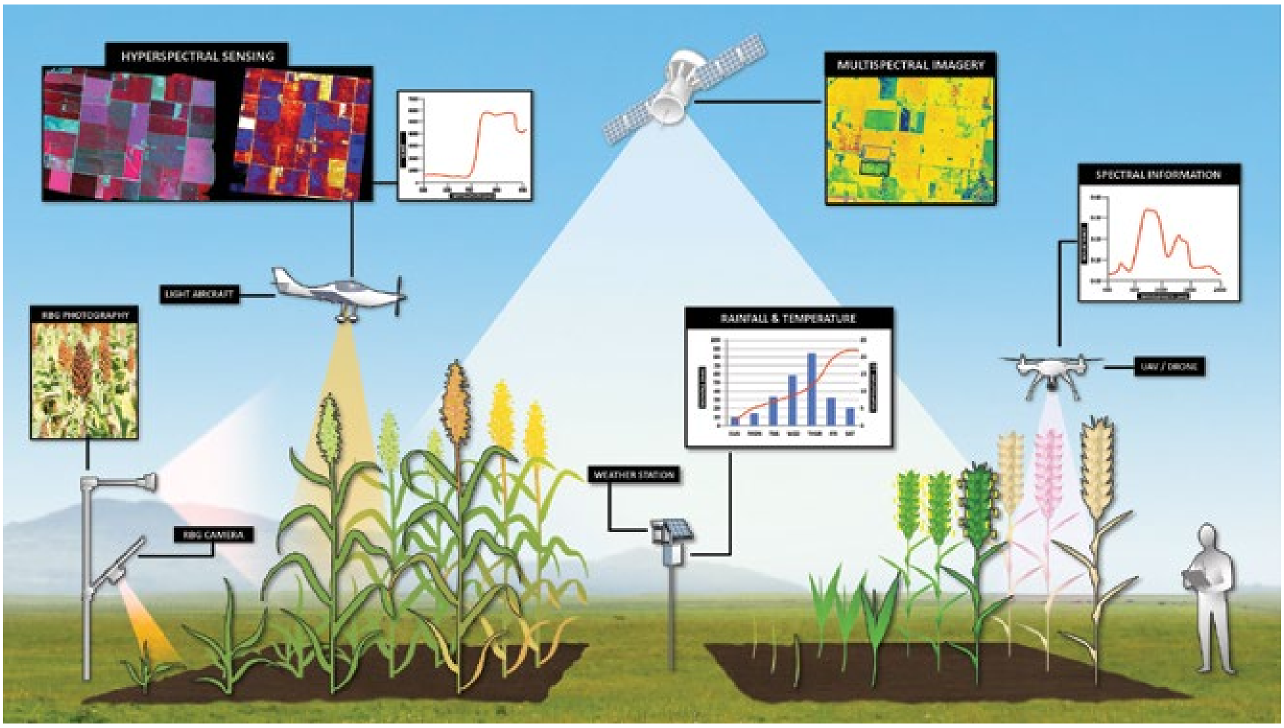
The authors first review remote- and proximal- sensing technologies. Currently, there are more than 140 earth observation (EO) satellites in orbit, carrying sensors that measure visible, infrared and microwave regions of the electromagnetic spectrum of terrestrial vegetation.

Remote sensing allows crops across large areas to be monitored over time and with precise repeated data. This data can be used (among other things) to discriminate between different crop types (e.g., wheat, barley, chickpeas and canola) and quantify cropping area at regional and landscape levels.

Recent advances in sensor technologies have led to the rapid increase in the use of drones or unmanned aerial vehicles (UAV) carrying proximal sensors. These sensors are deployed at the field level and have higher spatial and temporal resolution than remote EO sensors. This data can be used to monitor crop type, crop canopy and to quantify canopy structural and biophysical parameters (e.g. leaf area index, transpiration, photosynthetic pigments). Information from both platforms can be integrated for finer scale crop classifications.

The paper presents studies using remote sensing and UAVs along with the crops being assessed, sensors and algorithms. It also describes the pros and cons, as well as the applications for the senor types and sensor platforms commonly used with agriculture.

After the data is collected, algorithms are used to classify the remote sensing data. Traditionally, knowledge-based approaches are explicitly developed by experts using theory-based equations. The advance in computing power (e.g. cloud computing and high-resolution imagery) has led to the development of machine learning and more complex deep learning approaches. Machine learning



Proposed set-up of a multiple digital sensor platform to record information at a detailed crop validation site in recently funded GRDC project (CropPhen). This targets the development of new approaches for the accurate monitoring of crop phenology and discriminating of crop types (copyright QAAFI).

builds models directly from data without relying on predetermined equations. The strengths of machine learning include the capacity to handle data of high dimensionality and to map classes with very complex characteristics. The authors give specific examples of various machine learning and deep learning techniques.

Crop models deliver the predictive power of remote sensing data.

Crop models allow predictions of yield and phenological development stages for both current and/or projected climate scenarios. Combining real-time RS data with crop models can provide real-time information on crop growth and development and predict phenology and yield. The resulting tools are more important than ever as climate variability and change have an increasing influence on crop production and food security.

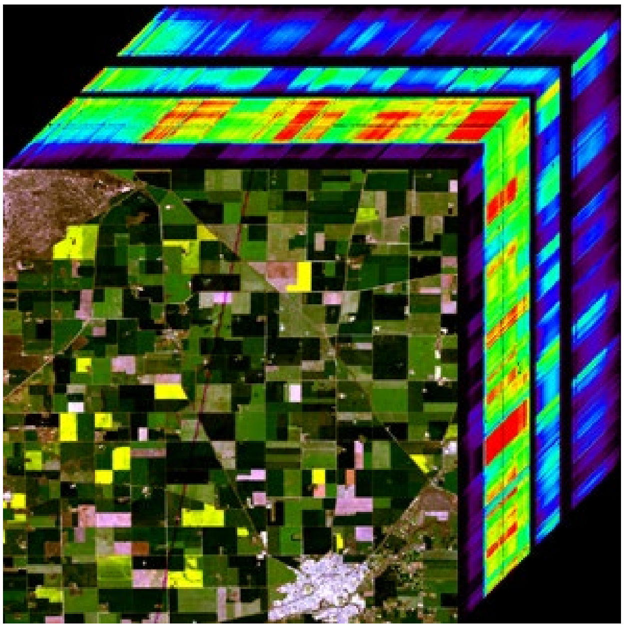
Information services based on remote sensing data are now available to the public via commercial platforms. The paper provides examples of these platforms and the information they provide.

What is the future of digital technologies in agriculture?

Crop growth and development are mainly a function of the interactions between genotype, environment, and management (G × E × M). Thus, these interactions are the key to realizing further gains in global crop yields and ensuring future food security. The environment cannot be changed but different cultivars (genotypes) can be planted with adjusting management practices (e.g. sowing dates, row spacings, seed density) tailored to the environment and future climate.

Farmers know that not all fields are equal: some always produce more, others always less, while other fields vary in their production capacity from one year to the next. “Planning for an average season does not make sense, since no rainfall season is the same across a farm in any given year”, Dr Potgieter said. Furthermore, the ability to make informed decisions from regional yield estimates are limited by this variability in G × E × M at a local scale.

Currently, no technologies are capable of effectively harnessing all dimensions of the targeted data available to achieve higher



PRISMA 3D hyperspectral cube © CropVision Team, QAAFI.

accuracies in crop phenology or crop-type estimation. A/Prof Potgieter is currently the lead on a national project (supported by GRDC and UQ) exploring new frontiers in application and/or developing novel metrics that can effectively harness all dimensions of the targeted data available to achieve higher accuracies in crop phenology or crop-type estimation.

“This will result in integrated solution to allow accurate development, validation, and scalability of predictive tools for crop phenology mapping (G) at within-field scales (M), across extensive cropping areas (E). Working closely with industry partners in the digital space it is anticipated that producers will have access to these digital tools that will aid them in making more informed decisions, targeted to the G X E X M for each field, early on. Thus, reducing input costs, enhancing risk management and improve whole-farm profitability,” said Dr Potgieter.

Originally published in Botany One online, 10 August 2021

Feathertop Rhodes grass. Stock image.

Fighting the familiar Feathertop foe

Feathertop Rhodes (FTR) grass is Queensland's top grass weed problem in summer fallows and crops in Central Queensland, the Darling Downs and Western Downs regions of southern Queensland, and in northern New South Wales.

Professor Bhagirath Chauhan

Previously a weed found along roadsides, fence lines and wasteland areas, FTR has now become an issue in cropping country, particularly where minimum or zero tillage has been practiced for several years. The prolonged use and reliance on glyphosate in the fallows of these cropping systems has assisted with a species shift towards this grass.

Professor Bhagirath Chauhan leads research at QAAFI on weed biology and weed management in different crops. He has vast experience in developing integrated weed management options using agronomic approaches (row-spacing, seeding rates, weed-competitive cultivars, etc.) in Australia and Asia and is an expert in and is an expert in improving the efficacy of glyphosate use.

Rate response (0, 187.5, 375 and 750 g a.i. per ha) to glufosinate applied to large FTR plants.

Controlling large Feathertop Rhodes grass in fallow

By C Benjamin, WeedSmart

Feathertop Rhodes grass (FTR) is a major weed in chemical fallows in Australia, and is notoriously hard to kill with glyphosate.

QAAFI weed biology and management expert Professor Bhagirath Chauhan, said some other herbicide control measures have potential to manage large FTR plants (40 to 50 leaf stage) that have escaped earlier treatment.

Professor Bhagirath Chauhan says there are some tank mixes and herbicide sequences that growers could deploy to help manage FTR and stop seed set.

"Feathertop Rhodes grass is an aggressive weed that can establish in bare fallow situations and produce a large quantitiy of seed if left uncontrolled," he said.

"Several biotypes of this species are resistant to glyphosate and can also survive a double knock of glyphosate followed by paraquat, particularly once the weed is larger than four to five leaf stage."

To give growers more options, a study was conducted to assess the potential of other herbicides and use patterns that can control large Feathertop Rhodes plants or stop seed set.

"An integrated approach is essential to controlling Feathertop Rhodes grass," Professor Chauhan said.

"In applying the WeedSmart Big 6 to FTR in a bare fallow situation we have identified some tank mix and herbicide sequences that growers could deploy to help manage this difficult weed and stop seed set."

Can anything be done to improve the efficacy of glyphosate or the double knock against large FTR plants?

In brief: Adjuvants did not improve glyphosate efficacy on mature (40 to 50 leaf) FTR plants. In glyphosate resistant populations, the second knock product is doing the heavy lifting when applied to large (8 to 10 leaf) FTR plants.

The details: None of the commercially available adjuvants improved the efficacy of glyphosate (740 g a.e. per ha) as a single product application on FTR at the 40 to 50 leaf stage. All the plants survived and produced seed after being treated with glyphosate, indicating that the population used in the study was resistant to glyphosate at this rate and weed growth stage.

Glyphosate and the double knock tactic can often provide good control of resistant FTR plants if the herbicide is applied when the plants are small and actively growing.

The traditional double knock of glyphosate (Group 9 [M]) or glyphosate + 2,4-D, followed by paraquat (Group 22 [L]) or glufosinate (Group 10 [N]), applied to older FTR plants (8-10 leaf) achieved increased phytotoxicity through improved mortality, reduced biomass or fewer seed panicles.

However, the double knock was no better than using paraquat or glufosinate alone when applied to 8 to 10 leaf FTR plants. FTR is not listed on glufosinate labels in Australia but is used to control other weeds in fallow situations at the rate (750 g a.i. per ha) tested in this study. For best results, glufosinate needs to be applied in warm, humid conditions, which is not a common scenario for summer fallow situations.

Are clethodim or haloxyfop suitable alternative herbicides to treat large, glyphosate resistant FTR plants?

In brief: Possibly. Excellent results were achieved in pot trials conducted in an open environment, but will be more difficult to achieve in the field.

The details: Clethodim and haloxyfop were tested on FTR plants at the 24 to 28 leaf stage. Clethodim is registered for use against FTR in a number of summer crops, but without any crop competition many FTR plants survived the registered rate (90 g a.i. per ha), although weed biomass and seed production was severely curtailed.

Haloxyfop efficacy against FTR at this growth stage was 100 per cent at the registered rate of 80 g a.i. per ha.

A combination of these two treatments also resulted in 100 per cent control. The effective use of these two herbicides (both Group 1 [A]) relies on excellent coverage and application when the plants are actively growing. This is difficult to achieve in field conditions, which is why the label recommendations are typically for younger weeds.

These herbicides are known to readily select for resistant biotypes so when applied in a chemical fallow situation (with no competition), it is necessary to target small weeds with robust application rates and to apply a second knock with a contact herbicide, such as paraquat.

Did you find any new and exciting prospects for controlling mature FTR plants?

In brief: Yes, it seems that there is a truly synergistic effect when isoxaflutole (Group 27 [H]; e.g. Balance) is mixed with paraquat.

The details: Neither of these herbicides provided useful control of FTR at the 40 to 50 leaf stage when applied individually. When mixed together, these herbicides achieved a higher level of weed mortality and prevented panicle production. For example, a tank mixture of isoxaflutole 75 g a.i. per ha, with paraquat 600 g a.i. per ha, resulted in 92 per cent FTR mortality and no panicle production.

Even at a paraquat rate of 300 g a.i. per ha mixed with isoxaflutole 75 g a.i. per ha, only 17 per cent of the large FTR plants survived when the mixture was applied to both the plant and the nearby soil – allowing uptake through both the leaves and the roots.

The benefit of this mixture may be reduced if the weed patch is dense, potentially reducing the amount of the isoxaflutole that reaches the soil. Even the prevention of seed set in large FTR plants is of significant value in managing the seed bank of this invasive weed, as FTR seed remains viable for less than 12 months.

Such a use pattern is not currently specified on product labels, although both products are registered for weed control in fallow situations.

Dr Jack Christopher

New tools for drought tolerant wheat

Highlights:

- Quantitative trait loci (QTL) were identified for stay-green traits of wheat.
- A multi-reference nested association mapping population sampled multiple genomes.
- This approach enabled identification of parent-specific alleles and context dependent expression.

L-R Dr Mandy Christopher, Dr Jack Christopher and Dr Alison Kelly

Wheat breeders can now improve the drought tolerance of their wheat cultivars thanks to a gene breakthrough from a joint QAAFI and Department of Agriculture and Fisheries (DAF) team of researchers.

Dr Jack Christopher and Dr Alison Kelly from QAAFI and Dr Mandy Christopher from DAF partnered to tease apart the complex genetics of stay-green in wheat.

Dr Mandy Christopher, Dr Jack Christopher and Dr Alison Kelly.

"Queensland wheat crops often experience water limitation at the end of the growing season," said DAF's Dr Mandy Christopher.

"Wheat cultivars that stay green for longer are better at maintaining yield under dry conditions.

"The genetics of this trait, however, are complicated. It makes it difficult for breeders to select for in the field."

The team used a uniquely structured population along with a new statistical method, especially developed for the research, to identify genetic regions involved in stay-green, while simultaneously developing breeding parents carrying the genes.

"We showed, that despite these challenges, breeding for stay-green, in combination with associated drought tolerance mechanisms, like root architecture or transpiration efficiency, can be effective," said Dr Christopher.

This breakthrough means Australian wheat breeders now have at their fingertips the tools they need to be able to develop cultivars with this valuable trait.

Their paper *QTL identified for stay-green in a multi-reference nested association mapping population of wheat exhibit context dependent expression and parent-specific alleles* has been published in the international journal *Field Crops Research* and involves input from DAF, QAAFI and CSIRO scientists.

This research forms part of a Grains Research and Development Corporation project into the delivery of wheat root traits that contribute to water limited yield stability.

Project leader Dr Brad Campbell checks wild taro

Dr Millicent Smith

DNA fingerprinting the food of Gods

Taro's unique nutritional and cultural importance to Pacific Islanders is under threat from climate change, but with the help of The University of Queensland, a project is underway to provide taro with genetic resistance to emerging environmental stresses.

Throughout the humid tropics, Pacific Islanders rely on the taro plant (*Colocasia esculenta*) to provide the core staple food in their diets.

Dubbed the 'food of Gods' in the Pacific west, taro is one of the oldest cropped plants in the world, with its cultivation dating back 10,000 years in Papua New Guinea.

Generations of accumulated traditional knowledge are at work in cultivating taro. This knowledge relates to seasonal variations in rainfall, temperature, winds and pollination.

The basis of these practices, however, are considered in jeopardy given the potential rate of disruption caused by climate change.

In 2019, the chief scientific organisation in the Pacific region, the Pacific Community *(SPC)*, launched a project to use advanced genomic technology to help futureproof taro production for its 26 member countries and territories. It is led by project leader Ms Logotonu Meleisea Waqainabete and Dr Amit Sukal.

The project is funded by the UN's Food and Agriculture Organization (FAO) and exploits technical expertise at the University of Queensland (UQ), where Professor Ian Godwin and Dr Bradley Campbell are continuing a legacy of Australian support to the SPC.

Exploiting genetic diversity

Dr Campbell explains that the latest project focuses on better exploiting the genetic diversity curated by the TaroGen genebank located in Fiji.

"The aim is to type the entire collection of over 2000 taro samples using DNA fingerprinting technology," Dr Campbell said.

"That will allow the genebank to catalogue genetic differences in their collection, an important innovation given that it's these differences that can result in resistance to environmental stresses."

The same technology platform will also deliver DNA markers that breeders can use to rapidly transfer stress tolerance genetics into cultivated taro varieties.

A prime concern is the increasing risk of tidal inundation that contaminates soil and freshwater with toxic levels of salinity.

Genetics that protect plants from salinity are known to exist in other staple crops and are an ongoing source of breeding efforts within Australian agricultural research programs.

To help the SPC find and exploit taro salinity tolerance genes, Dr Campbell, with the advice of UQ's Dr Mal Hunter, has developed two experimental systems. These make it possible to grow a large number of taro plants under conditions that make the presence of salinity tolerance obvious.

The aim is to develop and validate the technology at the University of Queensland prior to its transfer to TaroGen in Fiji.

These systems use specialised pots and hydroponics to expose taro plants to elevated salinity that mimics tidal inundation. Given the large numbers of plants needed to measure growth, Dr Campbell is seeking additional screening technology.

Advanced technology

"In Australia, we have come a long way in developing agricultural applications for hyperspectral cameras, which use light in the visible and infrared wavelengths to interrogate plant biology and physiology," Dr Campbell said.

"This is advanced technology that needs artificial intelligence to decode signals that are contained in the light reflected by a leaf. However, we think that a version of this technology based on affordable hyperspectral cameras can be made available to TaroGen."

The importance of being able to curate, differentiate and exploit genetic diversity in taro was previously highlighted in a dramatic fashion in the 1990s. At that time, an outbreak of fungal leaf blight disease wiped out Samoa's taro industry and created a biosecurity risk for other Pacific Islands.

That existential threat drove home the need for a genebank of highly diverse taro material that included disease resistance genes. It was that realisation that led to the establishment of TaroGen in the first place.

The move to adopt DNA fingerprinting technology is the next logical step in ongoing efforts to secure taro's important nutritional and cultural value.

The same technology also offers opportunities to include novel sources of genetic diversity not previously exploited by TaroGen and breeders.

Salinity tolerance

Of particular interest to the Australia and Pacific Science Foundation are wild Australian taro relatives that grow in marshy, saline habitats in and around south-east Queensland. These plants have evolved to tolerate salty environments and funding by the Foundation is allowing the University of Queensland researchers to identify and conserve this important genetic diversity.

"By applying these new technologies and insights, it is our sincere hope that the SPC acquires the means to stay abreast of emerging taro production challenges," Dr Campbell said.

"Importantly, we are dealing with technology that also empowers breeders to more rapidly exploit genetic diversity in order to meet the challenges of greatest concern to Pacific Islanders into the future."

Psilocybe cubensis © *Paul Vallier*

From magical mushrooms, to helping protect crops from dangerous pathogens, and world-leading research in avocado tissue culture propagation, variety is the spice of life for horticultural researchers at QAAFI.

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

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

Research expertise:
Horticulture crop breeding and agronomy | Plant protection | Emerging technologies

Professor Bronwyn Harch, DVC-RI UQ; Professor Matthew Morell, Director, QAAFI; Professor Neena Mitter, Hub Director and Director, Centre for Horticultural Science at UQ; Professor Deborah Terry, Vice-Chancellor & President, UQ; Professor Professor Aidan Byrne, Provost, UQ.

BioClay boosts "resilient and nature-positive agriculture"

A research hub dedicated to the application of a revolutionary alternative to chemical fungicides to protect Australia's $5 trillion global food and agribusiness sector was launched in Brisbane on Tuesday 9 November 2021.

The ARC Research Hub for Sustainable Crop Protection, headed by Professor Neena Mitter, builds upon on UQ's BioClay technology to create a 'smart' form of biological crop protection.

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

"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."

The Hub builds on UQ's innovative BioClay technology, which has been in development for almost a decade, that stimulates a plant's immune system to fight disease.

The 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 said.

Professor Deborah Terry:

"The Hub is combining this innovative technology with regulatory, commercial and social licensing expertise to encourage industry and consumer uptake of the product.

In addition to our commercialisation partner, Nufarm, more than 15 agencies are involved – too many to list now – across the higher education, agriculture, viticulture, and primary industries' sectors.

Collectively, these agencies have provided more than $13 million in funding and in-kind support for the Hub.

And, of course, we are immensely grateful to the Australian Government for $ 4.8 million in funding though the Australian Research Council.

It's a genuinely transformational opportunity that could help advance Australia's $60 billion agriculture industry and help achieve food security globally in a way that is consistent with the Paris Climate agreement and COP26 agenda.

It's hope for the future."

Professor Sue Thomas:

"The ARC Research Hub for Sustainable Crop Protection has been established to develop and commercialise an innovative biological alternative to chemical fungicides,

Central to the Hub's work, is the technology of 'BioClay', which uses clay particles to deliver targeted RNA into crops, to protect them from pathogens.

By protecting Australia's economically significant broadacre and horticultural crops, this Research Hub promises to increase productivity, market access, and enhance the environmental credentials of Australian food and wine.

Based at The University of Queensland, this Research Hub draws together funding and close collaboration from a total of 16 organisations – including four Australian collaborating universities:

- Griffith University;
- La Trobe University;
- The University of Tasmania; and
- Curtin University.

This impressive list of partners also includes Nufarm Australia, Ausveg, Bioplatforms Australia, and several research institutes and organisations at both state and federal level.

Working with these partners, the researchers at this Hub will establish Australia as a world-leader in biological-based fungicides and innovative agriculture."

QAAFI's Dr Madeleine Gleeson with 18mth old avocado tree at Bundaberg Qld farm.

Queensland science makes the avocado production bottleneck toast

The world's first Hass avocados produced by trees grafted on tissue culture plants are tasty, healthy, and disease-free, say University of Queensland scientists, who pioneered the break-through technology.

"Trials show that the clonal tissue culture rootstocks are yielding high-quality fruits in the field," said project leader Professor Neena Mitter, Director of UQ's Centre for Horticultural Science.

Economic modelling conducted by the University of Southern Queensland with the Department of Agriculture and Fisheries as part of the project suggests that the tissue culture technology offers a potential 21 per cent return on investment to avocado growers.

"This is a Queensland-owned and invented technology platform validated from lab to orchard, and is now progressing to commercial roll out," Minister for Agricultural Industry Development and Fisheries and Minister for Rural Communities Mark Furner said.

"Queensland produces the majority of Australia's avocados, and this innovation offers opportunities for growers across the state."

The tissue culture technology allows for up to 500 times more plants to be grown from a single cutting in 10-12 months – significantly reducing both resources required and the time it currently takes to produce a plant for sale in an orchard.

"We have been successful in rooting multiple industry-relevant avocado rootstocks using our meristem or plant stem cells-based approach to multiply plants," Professor Mitter said.

In trials funded by the Queensland Government's Advance Queensland Innovation Partnerships, tissue culture plants produced in a laboratory and then grafted with Australia's main avocado variety, Hass, have been successfully established in fields in Bundaberg, Tully, and Lakeland and two locations in Western Australia – Pemberton and Busselton.

Childers avocado grower Lachlan Donovan has been growing laboratory-propagated avocado trees for the past three years and said that he was pleased with the tree growth and harvest.

"In the past the delay between ordering new trees and planting has been two to three years," Mr Donovan said.

"The biggest advantage of this new technology for us is to be able to get desired rootstocks and varieties into production quickly."

A survey of Australian avocado industry members undertaken by Central Queensland University indicated that 72 per cent cannot access enough plants and nearly half indicated they already have the skills and knowledge to work with tissue culture trees.

The global avocado market was valued at USD 9.14 billion in 2020, with consumers embracing the health benefits of the fruit, which contains fibre, healthy fats and important nutrients.

"This is a sustainable technology that reduces the need for water, fertilisers, pest management processes and farming land used to produce rootstocks," Professor Mitter said.

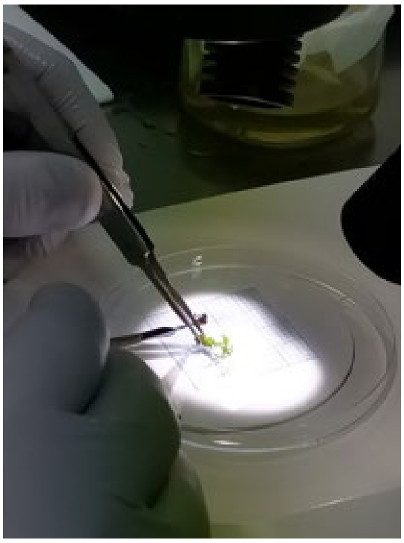
"With traditional avocado propagation, trees must be grown in fields for seed production.

"Another advantage with tissue culture propagation, particularly in this day and age, is that the movement of soil and the biosecurity risks this entails can be eliminated."

Professor Neena Mitter, industry partner Childers avocado grower Lachlan Donovan and QAAFI Director Professor Matthew Morell at the tissue culture pipeline industry workshop.

Gossia fragrantissima *Image: Public Domain Wikipedia*

Gossia fragrantissima *tissue culture cuttings (above and below)*



Race to save a remarkable native tree

An endangered native tree with a rare ability to accumulate normally toxic levels of metals in its leaves is being frozen in liquid nitrogen at The University of Queensland in a bid to conserve the species.

Dr Alice Hayward

UQ researchers aim to develop a successful protocol that will enable cryogenically frozen stems cells from *Gossia fragrantissima* to regenerate and grow into new trees.

"*Gossia fragrantissima* is an endangered myrtaceae family species and exists only in a few fragmented populations in north-eastern New South Wales to south-eastern Queensland," said plant molecular physiologist Dr Alice Hayward from the Queensland Alliance for Agriculture and Food Innovation.

"The plant has this rare ability to hyperaccumulate four different heavy elements – manganese, nickel, cobalt and zinc – but, like a lot of tropical and subtropical native species, it is unlikely to survive long term seed-banking to safely store genetic diversity."

"In addition, seed production of this *Gossia* species in the wild has been poor in recent due to climate impacts, disease and other stressors, so preserving the plant's unique genetic material is critical."

With funding from the Australian Flora Foundation, the research team led by Dr Chris O'Brien, is using tissue culture technology to propagate *Gossia* plants indoors, safe from the elements, and then cryopreserving the plant shoot tips in liquid nitrogen.

This high-tech approach to conserving the species' genetics is being undertaken in collaboration with UQ's Sustainable Minerals Institute (SMI) and the Royal Botanic Gardens and Domain Trust in Sydney.

Associate Professor Peter Erskinefrom SMI said that some *Gossia* species were of interest for their abilities as "hyperaccumulators" to extract metals from the ground.

"The genetics of these species is interesting and may help us to extract minerals from tailings during mine rehabilitation," Dr Erskinesaid.

Dr Erskine said the potential of these plants for rehabilitation and creating new resources depended on having enough plant material for large-scale trials.

"Not all species will not be suitable for this type of use – it depends on lots of factors, for example, how fast the plants grow and can be harvested, but the functional biology of Gossia that enables it to draw up four kinds of metals and store it life in leaf tissue is of particular interest.

Professor Bruce Topp's research aims to improve production and profitability for the macadamia industry. He is pictured at the world's highest density macadamia orchard trial site at DAF's Maroochy Research Facility. Photo: Megan Pope UQ.

Growers go nuts for new macadamia varieties

Queensland's macadamia industry is booming with up to 2.5 million trees to be planted in the coming years. Sales of four new DAF-licensed varieties have doubled year on year since 2017. The new varieties offer potential for significantly higher productivity for growers.

Queensland's macadamia industry is flourishing with tree sales soaring, and as many as 2.5 million trees to be established across growing regions in Queensland and New South Wales over the next few years.

Minister for Agricultural Industry Development and Fisheries Mark Furner said sales of four new DAF-licensed varieties had doubled year on year since 2017 and these high performing varieties offered the potential for significantly higher industry productivity.

"To ensure that growers can access sufficient licensed varieties, 21 nurseries have been accredited to provide planting material," he said.

"The Australian Macadamia Society estimates that by 2025, nut-in-shell production will grow from about 50,000 tonnes to 75,000 t.

"About three quarters of that yield is exported and the return for Queensland is in the 100s of millions of dollars."

The Minister said the Queensland Government was working closely with industry to support this rapid expansion.

"All of the major tree varieties commercially grown in Australia have been extensively evaluated through trials led by the Department of Agriculture and Fisheries (DAF)," he said.

"New varieties are being developed under the national breeding and evaluation program led by the Queensland Alliance for Agriculture and Food Innovation (QAAFI).

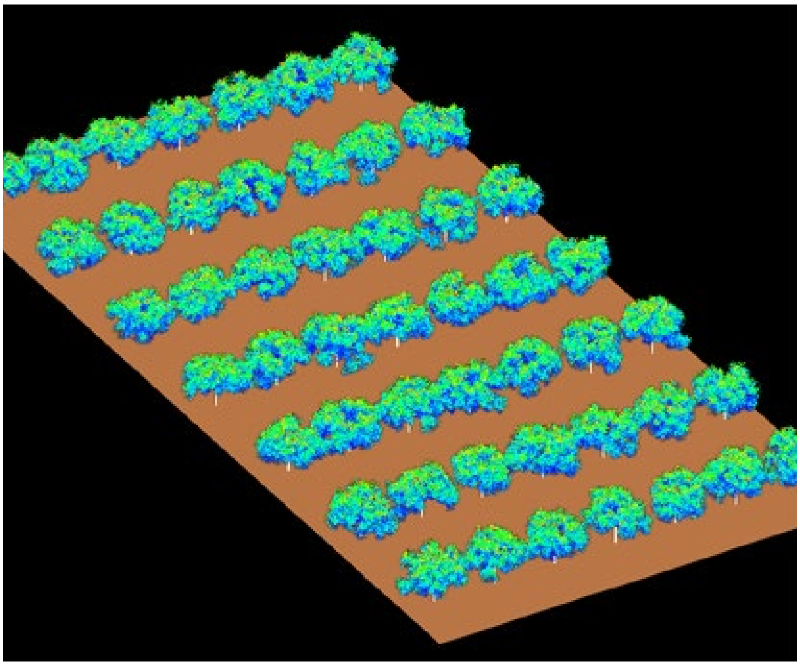
"DAF also assesses industry productivity and quality trends through the macadamia industry benchmarking project, while producing annual and long-term crop forecasts, contributing to the national tree crop intensification program, and assessing potential new rootstocks."

These projects were funded by Hort Innovation through the Macadamia R&D Fund with co-investment by the Queensland Government and our research partners.

Researchers are growing the highest density macadamia orchard in trial sites at Maroochy. Professor Bruce Topp is based at Maroochy.

Macadamia nuts. Image: QAAFI

LiDAR scanner mounted on back of ute © Liqi Han



Mango orchard model. © Liqi Han

‘Digital twins’ concept to boost food production

Computer simulations can run virtual experiments that speed up development of more productive, sustainable and climate-resilient food production systems.

Dr Liqi Han

Computers are changing how we produce food.

In a nod to technology familiar to computer gamers, scientists have started to generate virtual farming systems.

These ‘digital twins’ are used to run virtual experiments at a scale and speed never before possible.

In one example, the time needed to understand how to prune a fruit orchard to optimise sunlight capture was cut from upward of 40 years to just 26 minutes.

The result is an acceleration in innovation that will help make food production more productive, resilient and sustainable.

Researchers at QAAFI’s Centre for Horticultural Science are playing a world-leading role in the use of advanced computing in agriculture.

One of QAAFI’s lead researchers is Dr Liqi Han, who recently developed software to simulate experiments on mango orchards.

Dr Han said slow growing crops like fruit trees will especially benefit from the technology.

“We call this technology ‘DigiHort’, short for Digital Horticulture,” he said.

“The technology provides unprecedented opportunities for users to rapidly trial new ideas and acquire a reliable indicator of how to best optimise production systems.”

The computer simulations take three different forms:

1. **Conceptual designs**: A conceptual orchard design is based on an orchard that does not yet exist in reality but can be created within a computer.
2. **Digital twins:** a digital twin is a replica of a real-world orchard, mirroring it in fine detail.
3. **Digital variants:** Orchard management can be applied to the digital twin, creating a ‘digital variant’.

“All three forms can be integrated with environmental and management simulators,” Dr Han said.

“This might include sunlight and chemical spray simulations, for example, to allow for evaluation and optimisation of orchard management practice.”

Virtual trials are possible across all aspects of orchard management. It starts with the design of an orchard, with the software allowing users to decide where in a landscape to plant trees, the density of the canopies and the configuration of the rows.

It then extends to options for how the trees are maintained, allowing users to wield virtual pruners and test the impact of different – and even unconventional – tree training systems.

In addition, the QAAFI team can scan an actual orchard to generate a digital twin that mirrors a real-world production system.

This innovation is based on new LiDAR scanning technology applications that were undertaken with industry partner, Riegl Australia, and state government research stations in Queensland, Western Australia and Northern Territory.

The laser-based technology captures the architectural features of trees allowing the creation of a digital twin, down to the level of individual leaves.

These advances rely on High Performance Computing (HPC), which allows Dr Han to run extremely fast virtual experiments without loss of accuracy.

“These days, we talk more and more about precision agriculture,” Dr Han says.

“We enhance precision by looking at the details, such as how much light can be captured by each leaf or fruit, or the distribution of sprayed chemicals across the canopy.

“We can accumulate small benefits into big benefits or prevent big losses from occurring. Small differences can have a big impact.”

The DigiHort platform was designed as a decision-support service for industry and its simulation-evaluation-optimisation components will be accessible via the internet.

Psilocybe subaeruginosa cluster in Tasmania (c) Caine Barlow

Therapeutic potential of Australia's native magic mushrooms

Dr Alistair McTaggart

Australia's first legal, living collection of native magic mushrooms is being studied by scientists in a Brisbane laboratory to help identify characteristics that might be useful for medical research into psychedelic treatments.

"In Australia, it is estimated there are up to 20 species of magic mushrooms, some of which are native, while others have been introduced," said Dr McTaggart.

"They grow in dung or in leaf litter on damp forest floors.

"We are not certain of magic mushroom biodiversity in Australia, and we do not know how many species produce psilocybin – a psychoactive compound with effects similar to LSD."

More than 200 species of mushrooms worldwide are known to produce psilocybin.

In a new project underway at the Queensland Alliance for Agriculture and Food Innovation at UQ, Dr McTaggart will investigate the diversity of native magic mushrooms in Australia.

He said there was renewed global interest in the psychoactive properties of magic mushrooms for treating depression and post-traumatic stress disorder.

Dr McTaggart believes the global magic mushroom industry is where the medicinal cannabis industry was 15 years ago.

"Similar to the cannabis industry, mushrooms will need selection of genetic traits to upscale production or tailor different strains for different experiences," he said.

"Australian native magic mushrooms may have evolved different methods for psilocybin production and offer adaptations that are preferential for use in clinical treatments.

"Our new project will determine whether a species which is believed to be native, *Psilocybe subaeruginosa*, has spread globally.

"This species, or a close relative, is now the foundation of patents and research in Europe and the United States."

The cultivation, manufacture, possession, use and supply of psilocybin is illegal throughout Australia – including for native psilocybin-producing mushrooms.

"Consuming magic mushrooms can be dangerous – they can be mistaken for toxic mushrooms," Dr McTaggart said.

In another project in development, Dr McTaggart plans to use genomic sequencing to determine which species of native mushrooms in Australia are edible, poisonous or adaptable for medicinal use.

This work is funded through UQ's Research Support Program.

Nutrition and Food Sciences

Perfecting the plant-based burger patty. Photo: Motif Foodworks

Our research harnesses new technologies, science, and indigenous knowledge, to develop new food products, improve food systems, create healthy communities, and protect the integrity and safety of the global food supply chain.

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.

Our expertise:
Smart selections | Naturally nutritious | Uniquely Australian

A/Prof Heather Smyth with tray of plant-based patties. Photo: Megan Pope UQ

Plant proteins to 'meat' changing consumer demands

Professor Jason Stokes

For many people, nothing beats the taste and texture of a big juicy burger, but how do you recreate that eating experience with sustainable plant-based protein?

That is the culinary quest of University of Queensland engineers and food scientists as part of a three-year Australian Research Council project in partnership with US-based Motif FoodWorks, Inc., a food technology company on a mission to make plant-based food taste better and more nutritious.

Professor Jason Stokes from UQ's School of Chemical Engineering said attributes like taste, texture, and smell combined are primary drivers for consumers when considering a meat-free option.

"It's not just the taste, it has to be the texture as well, so the team wanted to understand the mechanics that occur during eating, and simulate them in a laboratory," Professor Stokes said.

"People want to continue to eat meat but supplement their diet with a plant-based protein.

"They've started to demand quite a bit from the product, and want it to have the same characteristics as a normal meat experience while also being healthy."

QAAFI's Associate Professor Heather Smyth said innovations around texture mechanics were the key to creating the best plant-based eating experience.

"Are there different ways of pre-treating plant protein in a way that makes it behave more meat-like in the first place, rather than just compensating burger formulations with various synthetic additives?" Dr Smyth said.

"This might include fermenting them, extracting them differently or structurally modifying the plant-protein.

"Making the plant protein behave differently as an ingredient is really the space where we can have those breakthroughs, and already we're seeing some interesting results."

"Through this work with the UQ team we're bringing together the physics and sensory aspects of eating," Dr Stefan Baier, Head of Food Science at Motif FoodWorks said.

"This project will unlock the secrets of food to help us design plant-based options that live up to the taste and texture expectations of consumers."

"We really have been leading this area of research for some time and that's why companies like Motif and others have come to us in Australia, even though we're a long way away from where they do their work," Professor Stokes said.

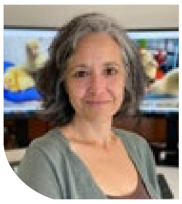
"The landscape's changed and people now recognise the challenges in food research, and they're large challenges in terms of how we perceive food and how we understand food, and rationally design and engineer their microstructure."

It's a challenge the team will tackle with relish.

Eggs involved in the research.

Dr Shahram Niknafs holding a chick

Essential oils may help gut health of new-age chicks



Dr Marta Navarro

Popular native Australian essential oils including tea tree oil and eucalyptus are being studied to determine if they better equip chicken embryos and hatchlings to fight disease.

University of Queensland researchers are investigating the benefits of essential oils for animal welfare, productivity and sustainability in the Australian chicken meat industry.

Professor Eugeni Roura from UQ's Queensland Alliance for Agriculture and Food Innovation said essential oils, which have pathogen-fighting properties, were being introduced into the diet of breeder chickens.

"We're determining if important essential oil compounds transfer through to the egg, and if they do, are they providing any significant benefit for the embryos' health and robustness," Professor Roura said.

"The most critical period in a broiler chick's life is the first hours after hatching.

"This is when the young bird is more susceptible to environmental pathogens, yet its defences and its natural gut microflora are not well established."

The research team, including project leaders Dr Marta Navarro and Dr Shahram Niknafs, is trialling Australian native essential oils including tea tree oil, lemon myrtle, nerolina, niaouli, lemon myrtle, anise myrtle, eucalyptus and Tasmanian native pepper.

"These native oils have reported strong antioxidant or disease-fighting attributes and have been extensively studied here at UQ," Dr Navarro said.

"This study is aiming to develop a nutritional program to minimise disease in chicks to enhance productivity and sustainability."

She said essential oils could affect how bacteria communicated and spread, inhibiting the formation of bacterial biofilms as an example.

"This may open new possibilities to target non-desirable populations of bacteria in the chick's gut while it is still in the egg," Dr Navarro said.

"Also, the oils can stimulate appetite and digestion to promote strong and vigorous early growth and development."

In a 'chicken or the egg' scenario, another strategy being tested involves injecting essential oils and nutrients into fertile eggs using *in-ovo* injection technology.

The researchers are measuring multiple parameters and indicators of gut health during trials including microbiome composition, growth, overall embryo development, and the stage of development following fertilisation.

"Once hatched, we're measuring the chick's growth and performance during the first 10-15 days of its life," Dr Navarro said.

"At the end of the project, we'll perform a trial with all the knowledge acquired during the project in commercial conditions."

This project is funded by AgriFutures Chicken Meat Program and supported by the Queensland Department of Agriculture and Fisheries and UQ.

Meat quality is not part of the scope of the project.

Djungan Paul Neal holds Burdekin Plum. Pic MPuls UQ

Dr Anh Phan demonstrates use of callipers to measure fruit to seed ratio – equipment included in the chemistry toolkit, Coopers Plains Lab, June 2021. Pic: UQ

Portable chemistry kit sweetens native bush fruit production

Professor Yasmina Sultanbawa

Indigenous communities can now assess the quality and sweetness of their wild-harvested native bush fruits in the field, rather than sending samples off to food science laboratories.

A prototype digital and portable bush fruits chemistry toolkit has been developed by UQ and QAAFI researchers for communities to use on site to measure key market attributes of popular bush fruits like Kakadu, Green and Burdekin plums.

"It will help support the knowledge already there in communities – by providing scientific measurements to support their own observations," said Professor Yasmina Sultanbawa, Director of the ARC Training Centre for Uniquely Australian Foods (UAF) at UQ.

"For instance, people in the community know which trees have the sweetest fruit – but now with help of the toolkit, they can measure the pH levels of fruit on the tree to get an external measure of its sweetness.

"In terms of product supply logistics, Indigenous enterprises and interested buyers need to know measurements like the weight and size of the fruit (its pulp to seed ratio); how much sugar and salt content and acidity levels are in the fruit; and moisture levels."

Professor Sultanbawa said this type of information was required to help understand the stability of the product, its suitability to be processed into a dehydrated powder, and to determine the type of packaging required.

"The bush fruits chemistry toolkit has been designed to address these questions and will be tailored according to the needs of each Indigenous enterprise, depending on their current activities along the value chain.

"By using the test kit to ensure consistently high-quality products, these enterprises are likely to get repeat, increased and new business, resulting in greater economic and social benefits delivered back into communities.

"Furthermore, the tool kit can be used to develop a secure and comprehensive database for each Indigenous enterprise to own and share with future generations.

"This database can store data and information about the different botanicals growing on country to help Indigenous enterprises and communities understand the effects of seasonality, genotypes, growing conditions, plant physiology through stress and responses to the changes of environments and connect to traditional knowledge and language.

The toolkit, which is also supported by funding from the Cooperative Research Centre for Northern Australia (CRCNA), can be used with any native bush fruit.

UAF and CRCNA project participant Ms Cate Cahill, Co-Founder of Kaiyu Superfoods said buyers of native bush foods required assessments on the quality and properties of the fruit.

"When we process Kakadu plum into powder, buyers want to know its moisture content, and other traits that the chemistry kit can measure this instantly."

Djungan Paul Neal, Community Development Program Manager at the Yarrabah Aboriginal Shire Council, whose community will house one of two chemistry test kits, said the kit empowered communities.

"It will allow us to monitor important information about our Burdekin plum trees so we can grow market access and build opportunities in the community.

"We will own the IP generated from our fruits."

The toolkit was developed by Dr Anh Phan, a Post-Doctoral Research Fellow with UAF, following consultations with Indigenous community members training in the assessment of the quality of wild-harvested bush fruits at UQ's Food Science laboratories in Brisbane.

It can be used to test fruit from each tree, to measure tree to tree attributes over seasons.

Professor Sultanbawa said the aim was to empower Indigenous enterprises with additional scientific knowledge about their food.

"By connecting science to traditional knowledge and caring for country you are building a provenance story for each of the bush foods that grow in the land owned by these Indigenous communities.

'The bush food value chains developed will be Indigenous, led, owned and controlled and this will enable greater participation of Indigenous enterprises in the food value chain.

Guidelines to protect intellectual property will be co-designed in consultation with the Indigenous communities working on these projects.

Professor Sultanbawa said the research team was investigating different sensing technologies communities could use on site to measure other key properties of their fruit, such as vitamin levels, traceability, and provenance.

Sensory genetics of fruit like papaya are under the microscope in new Hort Innovation project at QAAFI

Scientists imagine a future where consumers always like fruit

Fruit that tastes, smells and looks delicious every time could become a reality through a new $7M sensory genetics program coming out of Australia.

Delivered through Hort Innovation, and led and co-funded by QAAFI, DAF, and Griffith University, the research initially focuses on papaya, strawberries, mangoes, pineapples and passionfruit.

As part of the five-year project, a team of consumer, sensory and molecular scientists will work to determine exactly what today's shoppers want in their fruit – across the characteristics of flavour, colour, size, texture and smell.

Hort Innovation Research and Development Manager Dr Vino Rajandran said the research aims to enhance the overall sensory experience of Australians and those in export markets each and every time they bite into an Aussie-grown fruit.

"Studies show one bad fruit eating experience can turn a shopper off buying a fruit or vegetable," he said. "So the ultimate situation for a grower is to produce a good quality fruit that consumers love every time. This will lead to less food waste, at home and along the supply chain."

QAAFI Principal Research Fellow Professor Heather Smyth said there is a scarcity of reports that link consumer preferences of these traits with current market sectors or demographics.

"What we know is that consumer decisions are driven by personal beliefs; social aspects of production such as whether it is responsibly sourced and produced; price and finally the experience or sensory characteristics," she said.

"What we do not know enough about is the complex interplay of genetics that underlie the physical and sensory characteristics of fruit. Once sensory profiles for existing, and potentially new, characteristics have been established, we can naturally breed and select new varieties with the aim to eventually make them available to growers and consumers.

Mareeba papaya grower Gerard Kath said that providing a great eating experience every time is top of mind for his industry.

"Papaya production varies between the growing regions, but one thing that most growers agree on is that consistent papaya production, including fruit quality and flavour, is one of our highest priorities", he said.

DAF Senior Biotechnologist Dr Natalie Dillon said new varieties of mango, pineapple and strawberry are being developed through the Department's breeding programs and would target the tastebuds of consumers.

"We want to maintain the taste sensation of our most popular fruits, but also work on improving the flavour, aroma, texture, look and colour. We are mapping the crop genetics that underpin the consistency of producing quality fruit so growers can confidently meet market demand."

Dr Ido Bar, the lead researcher from Griffith University said this project aims to identify genetic and molecular pathways underpinning flavour and sensory profiles. "By integrating this new knowledge into the breeding programs, we could improve the consistency of fruit and enable the growers to match market demands," he said.

Supporting information

Employees and students of the Queensland Alliance for Agriculture and food Innovation - as of 31 December 2021.

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Dr Megan Vance	Postdoctoral Research Fellow
Dr Yuchan Zhou	Research Fellow

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Dr Sushil Dhital	Honorary Senior Fellow
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Mrs Sue Campbell	Centre Administration Officer/Coordinator
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Mr Cameron Doig	Research Partnerships Officer
Ms Cara Herington	Operations Manager
Ms Luba Hickey	Marketing and Communications Officer
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Mr Aaron Hughes	Facility Infrastructure Coordinator
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Mrs Emma Hassall	Research Technician, Sensory and Consumer Science
Ms Jessica Morgan	Program Coordinator

QAAFI Higher Degree by Research Candidates

Centre for Animal Science

Name	Program	Supervisor	Project Title
Miss Melissa Kaye Wooderson	PhD	Prof Alan John Tilbrook	PhD Analgesia and Haemostasis to achieve high standards of beef calf welfare in northern Australia
Ms Ai Hwee Kho	PhD	Dr Peter James	Detecting Haemonchus contortus infection in sheep using infrared spectroscopy
Ms Chian Teng Ong	PhD	Prof Alicja Elzbieta Tabor	Pathogenomics of infectious causes of bovine infertility in northern Australia
Mr James Patrick Copley	PhD	Prof Benjamin Hayes	Improving fertility in northern beef cattle with genomic selection
Mr Tristan Jacob Russell Wimpenny	PhD	Prof Timothy John Mahony	Identification of Molecular Factors Influencing Bovine alphaherpesvirus type 1 Replication Capacity and Virulence
Miss Emily Francisca Mantilla Valdivieso	PhD	Prof Alicja Elzbieta Tabor	Cattle tick and buffalo fly host biomarkers for resistance
Mr Harrison John Lamb	PhD	Dr Elizabeth Maree Ross	Crush side genotype to accelerate genetic gain in livestock
Dr Brandon Cameron Fraser	PhD	AsPr Luis Felipe Prada e Silva	Improving the nitrogen efficiency in tropically adapted cattle
Mr Jiali Zhang	PhD	Prof Mary Therese Fletcher	Stingless bee enzymes for biotransformation of cane sugar to a low GI sugar
Mrs Christie Louise Warburton	PhD	Prof Benjamin Hayes	Genomics approaches to improve productivity in cattle
Mr Zhi Hung Loh	PhD	Prof Mary Therese Fletcher	Mitigating the Effects of the Toxin Simplexin in Pimelea Poisoning of Cattle by Developing a Microbial Probiotic
Mr Muhammad Noman Naseem	PhD	Dr Peter James	Pathogenesis of buffalo fly lesions and factors determining variation in susceptibility amongst cattle
Mr 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
Mr Russell James Gordon	PhD	Prof Mary Therese Fletcher	Mitigating the effects of the plant toxin Simplexin on Australian livestock
Miss Xiaochen Sun	PhD	Dr Cornelia Turni	Studies on Glaesserella australis
Mrs Sadia Afreen Chowdhury	PhD	Prof Mary Therese Fletcher	Authentication of uniquely Australian food products with claimed health benefits
Mr Chensong Chen	PhD	Prof Benjamin Hayes	New mate allocation strategies to accelerate genetic gain in agricultural species.
Ms Seema Yadav	PhD	Prof Benjamin Hayes	Optimising genomic selection in sugarcane
Mrs Mst. Sogra Banu Juli	PhD	Prof Alicja Elzbieta Tabor	Campylobacter fetus genomics and host biomarkers for bovine genital campylobacteriosis immunity.
Ms Shreya Bardoloi	PhD	Prof Benjamin Hayes	Ag stack - using machine learning to rapidly stack chromosome segments to breed optimal crop varieties and livestock
Mr Stephen Baldwin	MPhil	Prof Timothy John Mahony	The Development of Novel Approaches for the Detection of the Pathogens Associated with Bovine Respiratory Disease.
Ms Katelyn Tomas	PhD	Prof Alan John Tilbrook	Early life stress and subsequent stress resilience and emotionality in pigs
Miss Tatiana Elle Briody	PhD	Prof Timothy John Mahony	Identification of the host and viral transcripts that are post-transcriptionally regulated by the microRNAs encoded by bovine herpesvirus 1
Mr Morteza Moradidivkolaie	MPhil	AsPr Luis Felipe Prada e Silva	Use of nitrogen metabolism parameters to identify feed efficient animals and estimate nitrogen excretion
Mr Hans Stephen Arthur Yates	MPhil	Prof Mary Therese Fletcher	Atypical saccharides in emerging and novel foods

Centre for Crop Science

Name	Program	Supervisor	Project Title
Mr John Edward Smith	PhD	Prof Michael John North Bell	The impact of irrigation methods and management strategies on nitrogen fertiliser recovery in cotton in southern QLD
Ms Colleen Hunt	PhD	Prof David Jordan	Improved methods of predicting genetic merit in plant breeding programs using linear mixed models
Mr Basam Julian Tabet	PhD	Prof Ian Douglas Godwin	Manipulating sorghum grain size and plant architecture
Ms Mengge Zhang	MPhil	AsPr Lee Thomas Hickey	Investigating the genetics and value of root traits to support yield in barley
Ms Dipika Roy	PhD	AsPr Lee Thomas Hickey	Understanding the genetics of spot blotch resistance in barley
Ms Mengwei Li	MPhil	Dr Joseph Xavier Eyre	Sorghum and maize establishment in cold and drying soils
Mr Sana Ullah Khan	PhD	AsPr Lee Thomas Hickey	Accelerated genome editing to speed up genetic gain in crops
Miss . Geetika	PhD	Dr Nageswararao Chenchu Rachaputi	Physiological determinants of potential yield in mungbean (Vigna radiata (L.) Wilczek)
Mr Richard Alexander Dixon	PhD	Prof Ian Douglas Godwin	Modification of root system architecture to increase climate resilience in barley
Miss Louisa Isabella Hallett	PhD	Dr Karen Massel	The Role of PIN Genes in Sorghum and Barley Architecture
Mr James Lawrence McLean	MPhil	Prof Daniel Rodriguez	Proximal sensing as a tool to assist data collection in extensive maize and sorghum agronomic trials
Ms Kanwal Shazadi	PhD	Dr Karine Chenu	Can genetic variations in root architectural development during the crop cycle affect wheat productivity in water-limited environments?
Mr Donald McMurrich	MPhil	Prof Ian Douglas Godwin	Canopy Manipulation of Sorghum to create a more efficient, stress tolerant plant with increased yield.
Mrs Prameela Rani Vanambathina	PhD	Dr Nageswararao Chenchu Rachaputi	Assessment and identification of molecular markers underpinning for H. armigera Hubner resistance in Australian wild Cajanus species
Mr Asad Muhammad Khan	PhD	Prof Bhagirath Singh Chauhan	Biology of Amaranthus retroflexus and Amaranthus viridis
Miss Xiaoyu Zhi	PhD	Dr Barbara George-Jaeggli	Hyperspectral sensing methods and genome-wide association studies to improve photosynthetic capacity in sorghum
Ms Yasmine Lam	PhD	Prof Ian Douglas Godwin	Analysis of PIN and VRN families in cereals to manipulate plant architecture
Mr Mahendraraj Sabampillai	PhD	Dr Nageswararao Chenchu Rachaputi	Effect of temperature, photoperiod and radiation on phenology, vegetative and reproductive growth in pigeonpea genotypes
Ms Virginie Perlo	PhD	Prof Robert James Henry	Metabolic and Transcriptomic Changes in the Developing Sugarcane Culm Associated with High Yield and Early-Season High Sugar Content.
Mr Asad Amin	PhD	AsPr Lee Thomas Hickey	Integrating crop modelling and genomics to improve plant breeding
Mr Albert Chern Sun Wong	PhD	Prof Andrew Kenneth Borrell	Manipulation of plant architecture genes in sorghum to manage drought adaptation
Miss Adhini Sudhindrakumar Pazhany	PhD	Prof Robert James Henry	Expression genomics to widen the gene pool of sugarcane for improved biomass partitioning
Mr Zerihun Tadesse Tarekegn	PhD	AsPr Lee Thomas Hickey	Integrating speed breeding and association mapping strategies to identify and introgress genes for key pathology and agronomic traits in bread wheat in Ethiopia
Mr Uwe Grewer	PhD	Prof Daniel Rodriguez	Bio economic modelling of farming systems under climate change for ex ante assessments of agricultural development policies
Mr Tolera Keno Fufa	PhD	Prof Ian Douglas Godwin	Identification of heterotic pools in maize germplasm adapted to mid altitude sub humid agro-ecology of Ethiopia
Ms Sharmin Hasan	PhD	Prof Robert James Henry	Diversity of domestication loci in wild rice populations.
Mr Othman Mubarak O Aldossary	PhD	Prof Robert James Henry	Jojoba Genomics for Stress Tolerance
Mr Bader Yousef Alsubaie	PhD	Prof Robert James Henry	Jojoba Genomics for Sex Determination

Mrs Galaihalage Kalpani Sachinthika Ananda	PhD	Prof Robert James Henry	Sorghum Genomics: Diversity and evolution of the Sorghum genus and the role of cyanogenesis
Mr Muhammad Yahya	PhD	Dr Karine Chenu	Mechanisms to improve grain yield and grain quality under heat in wheat
Mrs Charlotte Rambla	PhD	AsPr Lee Thomas Hickey	Optimising root systems in wheat
Ms Amy Christina Mackenzie	PhD	Dr Sambasivam Periyannan	Protecting wheat from stripe rust disease through rapid transfer of resistance from landraces
Ms Vallari Chourasia	PhD	Prof Robert James Henry	Catalytic Conversion of Sugarcane Bagasse into Aromatics and High- Value Platform Chemicals
Mrs Angela O'Keeffe	PhD	Prof Robert James Henry	Genetic solutions for determining fibre quality traits in sugarcane
Miss Priyanka Sharma	PhD	Prof Robert James Henry	Macadamia Genomics
Mr Muhammad Abdullah	PhD	Prof Robert James Henry	Rice gene editing
Mr Oluwaseun Johnson Akinlade	PhD	AsPr Lee Thomas Hickey	Understanding the genetics of crop root architecture
Ms Lipy Adhikari	PhD	Prof Daniel Rodriguez	De-risking Broadacre Cropping Options in Northern Australia
Ms Upuli Samurdhika Nakandala	PhD	Prof Robert James Henry	Citrus Genomics
Mrs Manatunga Mudiyanselage Sachini Lakmini Manatunga	PhD	Prof Robert James Henry	Genome diversity in the Macadamia genus
Ms Yichen Kang	PhD	AsPr Lee Thomas Hickey	Improving root system architecture of future crops
Miss Shanice Van Haeften	PhD	AsPr Lee Thomas Hickey	New tools and insight to breed high yielding mungbean varieties with synchronous flowering
Mr Daniel Ajaku Otwani	PhD	Dr Emma Sian Mace	Exploring the genome landscape of heterosis in sorghum
Ms Ngoc Lan Anh Huynh	PhD	AsPr Andries Bernardus Potgieter	Determining crop growth and crop type attributes from hyperspectral sensing & environmental data utilising and machine learning algorithms.

Centre for Horticultural Science

Name	Program	Supervisor	Project Title
Mr Christopher Michael O'Brien	PhD	Prof Neena Mitter	Cryopreservation of avocado shoot tips for the conservation of Persea germplasm
Ms Emily Kathryn Lancaster	PhD	Prof Andre Drenth	Epidemiology, impact and management of myrtle rust in Lemon Myrtle plantations
Ms Thi Phuong Thuy Mai	PhD	AsPr Bruce Leonard Topp	Genomic-assisted exploitation of wild germplasm for improvement of macadamia
Mrs Thu Ha Ngo	PhD	AsPr Andrew David William Geering	Post-translational processing of the caulimovirid capsid protein and utilisation of antipeptide antibodies for diagnosis
Ms Jasmine Nunn	PhD	AsPr Bruce Leonard Topp	Genetic variation in Macadamia for resistance to Husk Spot, Pseudocercospora macadamiae
Miss Eugenie Lessin Fatafehi Singh	PhD	AsPr Elizabeth Kathryn Dann	Investigating fungi causing fruit stem end rot and branch dieback in avocado
Ms Vheena Mohankumar	PhD	AsPr Olufemi Akinyemi Akinsanmi	Biology and epidemiology of Botryosphaeria associated with branch dieback and tree death in macadamia
Mr Ritesh Gyanchandaji Jain	PhD	Prof Neena Mitter	Topical application of RNA interfrence to manage insect pests of horticultural crops
Mr Stephane Andre Pierre Kern	PhD	AsPr Craig Hardner	Choice analysis evaluating factors influencing horticultural crop cultivars adoption and how those are accounted for in bio-economic modelling
Miss Yunjia Yang	PhD	Dr Karishma Trilok Mody	Topical RNAi for sustainable Animal Health
Mr Alexander Tomas Nilon	PhD	Prof Neena Mitter	BioClay for Control of Tomato Spotted Wilt Virus

Mrs Sari Nurulita	PhD	AsPr John Edwin Thomas	Virus-Infected Garlic in Australia and Indonesia, and Factors Affecting Disease Epidemiology
Mr Pratyush Ravichander	PhD	Prof Neena Mitter	Topical application of RNA interference targeting plant fungal diseases
Miss Jane Denise Ray	PhD	Prof Andre Drenth	Biology and Epidemiology of Banana Blood Disease
Mr Mohamed Zakeel Mohamed Cassim	PhD	AsPr Olufemi Akinyemi Akinsanmi	Unravelling the cause of abnormal vertical growth in macadamia
Miss Fernanda Yuri Borges Naito	PhD	AsPr Ralf G Dietzgen	Differential plant gene expression in response to tospovirus and rhabdovirus infection and viral counter-defense
Mr Michael Bird	PhD	AsPr Craig Hardner	Maximizing gains from selection in Eucalyptus
Mr Jed Calvert	PhD	Dr Roger Graham Shivas	Biotic and abiotic drivers of microbial community structure in rainforests of the Australian Monsoon Tropics
Mr Hsu-Yao Chao	PhD	AsPr Andrew David William Geering	Improving surveillance strategies for tospoviruses and thrips to enhance the biosecurity of the nursery industry
Mr Kandeeparoopan Prasannath	PhD	AsPr Olufemi Akinyemi Akinsanmi	Etiology of flower blight complex in macadamia
Mr Onkar Nath	PhD	Prof Neena Mitter	Improving avocado through genomic analysis
Mr Yuxin Xue	PhD	Prof Neena Mitter	Propagation and Genetic Enhancement of Duboisia Species for Production of Tropane Alkaloids
Ms Bao Tram Hoang	PhD	Prof Neena Mitter	Investigating the Fate of Topically Applied dsRNA in the Environment
Miss Wei-An Tsai	PhD	AsPr Ralf G Dietzgen	Exploring the involvement of small RNA response in capsicum defence against capsicum chlorosis virus at elevated temperature
Mr Jacob Jose	PhD	AsPr Elizabeth Kathryn Dann	Investigating the phosphonic acid-mediated suppression of Phytophthora cinnamomi in avocado
Mr Daniel Anthony Edge-Garza	PhD	AsPr Craig Hardner	Global prediction for genetic improvement of apple
Mr Jian Cao	PhD	Dr James Scott Hanan	High performance computing and computational modelling for studying the influences of orchard designs and practices on light interception
Mr Norman Munyengwa	PhD	AsPr Craig Hardner	Genomic prediction in mango
Mr Jahangir Khan	PhD	AsPr Olufemi Akinyemi Akinsanmi	Investigating the epidemiology, impact and management of biotic agents in macadamia nurseries in Australia
Mrs Pragya Dhakal Poudel	MPhil	Dr Mohammad Alam	Investigating Rootstock mediated vigour control in macadamia

Centre for Nutrition and Food Sciences

Full Name	Program	Supervisor	Project Title
Mr Adam O'Donoghue	PhD	AsPr Timothy James O'Hare	Assessing the bioactivity of tomato extracts from varieties with unique carotenoid profiles on human in vitro prostate cancer cell lines
Mr Michel Mubiayi Beya	PhD	Prof Louwrens Christiaan Hoffman	Effects of Antimicrobial and Antioxidant Activities of Australian Native Plant Extracts on The Safety and Quality of Value-added Meat Products
Mr Alexander Trung Chanh Bui	PhD	Prof Michael Gidley	Mechanisms of Resistant Starch Breakdown by Gut Microbiota Using High Amylose Wheat
Miss Jasmine Sin-Yue Ngo	PhD	AsPr Heather Eunice Smyth	Understanding compositional-physical relationships with texture and mouthfeel of coffee mixer beverages
Ms Carla Andrea Castro Tabilo	PhD	Prof Eugeni Roura	Peri-hatching strategies to endure enteric pathogens in broilers account
Mr Wei Hu	PhD	AsPr Timothy James O'Hare	Endogenous fatty acid desaturation of palmitic to palmitoleic acid in macadamia kernel tissue.

Mrs Selina Anne Fyfe	PhD	Prof Yasmina Sultanbawa	Characterising the potential of the green plum (Buchanania obovata) as a native Australian fruit
Ms Astrid Del Rocio Coba Cedeno	PhD	Prof Eugeni Roura	Heat Tolerance (HT) in lactating sows: dietary strategies, metabolic biomarkers and microbiome signature
Mr Yeming Bai	PhD	Prof Michael Gidley	Pectin's effect on starch digestion: in vitro explorations based on molecular structure-property relationships
Ms Shammy Sarwar	PhD	Prof Yasmina Sultanbawa	Impact of photosensitization on the nutrient profile and bioaccessibility of bioactive compounds in Australian grown strawberries
Miss Caili Li	PhD	Prof Michael Gidley	High-amylose wheat flour as a nutritional component in foods
Mr Zeping Shao	PhD	Prof Eugeni Roura	Phenotype and genotype association between food allergy and taste
Miss Shiyi Lu	PhD	Prof Michael Gidley	In vitro gut microbial fermentation of models for plant dietary fibre
Mr Eshetu Mulisa Bobasa	PhD	Prof Yasmina Sultanbawa	Impact of wild harvest, region and processing on the quality and functionality of Terminalia ferdinandiana Exell fruits
Mrs - Widaningrum	PhD	Prof Michael Gidley	In Vitro Fermentation of Insoluble Dietary Fibers and Undigested Fractions from Plant Food Sources
Mr Maximiliano Jose Muller Bravo	PhD	Prof Eugeni Roura	Dietary amino acid excesses and appetition in weaned pigs
Mrs Batlah R B Almutairi	PhD	Prof Yasmina Sultanbawa	Developing a new probiotic fermented milk with prebiotics for aflatoxin M1 detoxification
Miss Gengning Chen	PhD	Prof Yasmina Sultanbawa	Exploring the nutritional quality and food functionality of Burdekin plum (Pleiogynium timorense)
Mrs Gayathri Rajagopal	PhD	Prof Yasmina Sultanbawa	A bioeconomic model for valuing the unique biodiversity of wild harvested Australian native foods products for commercial markets
Mr Oladapo Oluwaseye Olukomaiya	PhD	Prof Yasmina Sultanbawa	Utilization of solid-state fermented canola meal, camelina meal and lupin as potential protein sources in the diets of broiler chickens
Mrs Elisabet Garcia Puig	PhD	Prof Eugeni Roura	Slowing down intestinal passage rate to decrease diarrhoea risk and ZnO dependence in weaned piglets
Mr Dongdong Ni	PhD	Prof Michael Gidley	Food and human factors contributing to food intake & appetite (satiation and satiety)
Mr Shaoyang Wang	PhD	AsPr Heather Eunice Smyth	A Systematic Approach to Understand Wine Astringency and Mouthfeel
Ms Sera Susan Jacob	PhD	Prof Michael Gidley	Wattle seeds for nutritional foods
Mr Tatsuyoshi Takagi	PhD	AsPr Timothy James O'Hare	Factors affecting flesh colour of mango fruit (Mangifera indica) and subsequent potential health benefit.
Mr Madan Kumar Chapagai	PhD	Prof Michael Gidley	Preparation and characterization of chemically modified wheat starch as a depressant of pyrite and graphite
Mr Miaomiao Zhou	PhD	Prof Eugeni Roura	Starch and lipids in food: structural effects on brain function
Mrs Sally Jean Taylor	PhD	Prof Eugeni Roura	How to make antibiotics in pig feed redundant, naturally
Ms Rimjhim Agarwal	PhD	AsPr Timothy James O'Hare	Identification of genetic variants in orange-pigmented capsicum and chillli of the Capsicum annuum, C. chinense, and C. baccatum species.
Ms Maral Seididamyeh	PhD	Prof Yasmina Sultanbawa	Use of Novel Green Technologies for Preservation of Horticultural Produce using Plant Bioactives
Mr Hong Yao	PhD	Prof Michael Gidley	Microbiome responses to food carbohydrates
Mr Michael Che-Kwang Ryoo	MPhil	Prof Eugeni Roura	How to make antibiotics in pig feed redundant, naturally
Mr Shanmugam Alagappan	PhD	Prof Louwrens Christiaan Hoffman	Compositional analysis and Technological characteristics of Australian Edible Insects as Food Source
Mr Oladipupo Qudus Adiamo	PhD	Prof Yasmina Sultanbawa	Extraction and Characterization of Bioactive Peptides with Antioxidative and Angiotensin-Converting Enzyme Activities Derived from Proteins of Australian Acacia sp.
Mr Apurba Lal Ray	PhD	AsPr Timothy James O'Hare	Genetic factors affecting anthocyanin development in purple-pericarp sweetcorn

Miss Kodagoda Hitige Gethmini Kavindya Kodagoda	PhD	Dr Michael Erich Netzel	Assessment of the nutritional quality of Australian grown Plumcot
Mrs Sukirtha Srivarathan	PhD	Dr Michael Erich Netzel	Nutritional quality of selected Australian native fruits and Australian grown produce
Mr Asad Ali	PhD	Prof Eugeni Roura	Peri-hatching strategies to endure enteric pathogens in broilers
Mrs WWM Upendra Kumari Wijesundara	PhD	Dr Agnelo Furtado	Mango Genomics
Ms Saskia Urlass	PhD	AsPr Heather Eunice Smyth	Australian native seaweed for diet diversification
Miss Mila Margaretha Yolanda Meijer	PhD	Prof Eugeni Roura	Peri-hatching strategies to endure enteric pathogens in broilers
Mr Nicola Tandurella	PhD	AsPr Heather Eunice Smyth	Quality of Australian Honey from Native Botanicals
Miss Clare Elizabeth Wijngaarden	PhD	AsPr Heather Eunice Smyth	Market Insights for Australian Native foods
Mr Ramanah Visnupriyan	PhD	AsPr Daniel Cozzolino	High throughput monitoring of the human digestion process using a simulated dynamic system and sensing technologies

Publications

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Book

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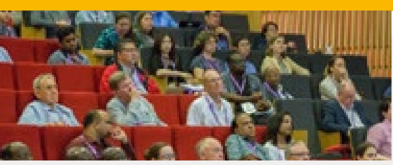
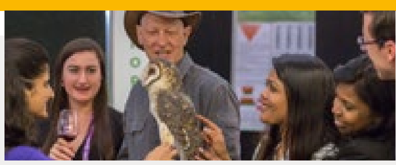

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