SEGMENT

ISSUE 6

Food. Environment. Society.

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Flowering dragon fruit cacti growing in Kerikeri. This is the home of Plant & Food Research's pilot trial to test whether this could be a new commercial crop for Aotearoa New Zealand. This trial was developed as part of a collaboration between Viet Nam and New Zealand for over a decade to create disease-resistant, high-yield dragon fruit varieties while promoting sustainable practices and strengthening links between the two countries. Page 30.

IMAGE BY BEN LAWRENCE

Inside

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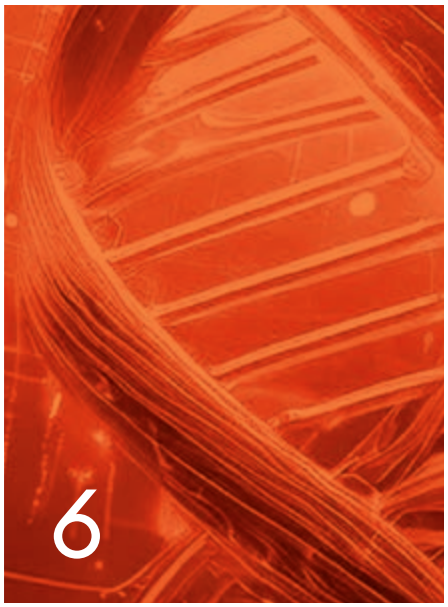


FEATURES

REGULARS

INSIDE SLICE

A look inside Plant & Food Research

Welcome to Issue 6 of Segment magazine

Welcome to the latest issue of Segment magazine, where we explore how new technologies and knowledge systems are being incorporated into food production.

New thinking is needed to address big challenges, such as the increasing global population and changes to climate, at a faster pace than is possible with current technologies. Artificial intelligence, robotics and biotechnology are growing at a rapid pace, and incorporating these into production systems and product development will generate new concepts and improve efficiencies.

In this issue, Richard Rennie explores how gene technologies are being used in the development of new food products; Matt Philp investigates how artificial intelligence has been incorporated into existing supply chains; and Veronika Meduna discusses some of the new thinking required for science and indigenous knowledge to work together.

We discuss food marketing and sustainability with Jiunn Shih from Zespri, and our photo story takes a behind-the-scenes look at dragon fruit production, both in Viet Nam and New Zealand.

We hope you enjoy learning more about how food production systems are adapting over time.

Mark Piper
CEO Plant & Food Research

The science of scent

Researchers at Germany's Fraunhofer Institute have developed a machine learning algorithm capable of identifying the five strongest aroma notes in whiskies and predicting their origin – US or Scotland – with over 90% accuracy. The artificial intelligence outperformed a panel of Whisky Masters in consistency and precision, using molecular data from 16 whiskies to pinpoint chemical markers. While supporting, not replacing, human expertise, AI offers the potential to enhance whisky consistency across batches and detect counterfeiting.

Morning brew for a longer life

A new study from Tulane University suggests drinking coffee only in the morning may promote longevity. Analysing data from over 40,000 adults, researchers found morning coffee drinkers had a 16% lower risk of death and a 31% reduced risk of heart disease compared to non-drinkers. Published in the European Heart Journal, the study highlights coffee's potential benefits when consumed before noon, possibly due to its alignment with the body's natural sleep cycles.

Electric fungi

Fungi could be used to power batteries in remote regions thanks to a new breakthrough by researchers from the Swiss Federal Laboratories for Materials Science and Technology. The fungal battery is 3D-printed – with fungal cells mixed into the printing ink – and has the unique advantage of being biodegradable. Once it's served its purpose, the battery digests itself from the inside.

A natural boost for mood

Scientists at Plant & Food Research and Callaghan Innovation have discovered a novel molecule sarmentosin, which is found in New Zealand blackcurrants. Sarmentosin acts as a natural inhibitor of the Monoamine oxidase-B (MAO-B) enzyme. MAO-B enzymes break down important brain chemicals, like dopamine, which plays a key role in mood and mental performance. The clinical study, published in The Journal of Agricultural Chemistry, identified sarmentosin as the primary inhibitor of MAO-B enzymes in the human brain after consuming blackcurrant products. This finding suggests that consuming blackcurrant powder and juice may positively affect mood and mental fatigue in healthy adults.

Boosting potato nitrogen efficiency

Researchers from the Centre for Research in Agricultural Genomics in Barcelona have found that the same genetic mechanism that tells potatoes when to grow flowers and tubers is also a key player in the plant's nitrogen management. The findings could lead to the development of potato varieties that require less fertilizer, saving farmers money and reducing the environmental footprint of potato cultivation.

New method extracts more protein from seaweed

Researchers at Chalmers University of Technology in Sweden have discovered a promising method for extracting proteins from sea lettuce, an alternative to meat and other protein sources. This new extraction technique is three times more efficient than previous methods, making seaweed a more viable option for human consumption. In addition to improving the extraction process, the researchers are exploring ways to enhance the protein content of sea lettuce. By cultivating the seaweed in nutrient-rich process water produced by the seafood industry, they found that the protein content of the sea lettuce significantly increased. This method not only purifies the process water but also results in seaweed with a higher protein content.

FEATURE

Changing world for gene technologies

BY RICHARD RENNIE

Amongst scientists there has been a collective 'hurrah' to news that governments around the world are revisiting and revising rules around the use of gene technologies in food production.

The New Zealand Government has recently suggested changes to gene technology use that could have massive economic and environmental benefits. Some of New Zealand's key trading partners, such as the USA and Japan, have already updated their regulations to more easily allow gene-edited crops to be grown and sold in market. Others, such as the UK and Europe, are on a similar path.

Scientists around the world are doubling down on efforts to deliver gene-edited foods that meet growing environmental and consumer pressures, with several available to consumers already.

Diving into gene editing

Canada, Australia, Japan, the United States and China are all taking an increasingly liberal approach to allowing gene technology to be used in commercial food items and crops.

Canada, for example, believes that, scientifically, gene-edited crops do not present any unique concerns compared with crops produced via other development methods.

Guidelines set in 2023 on crops developed through gene editing and other New Breeding Techniques (NBTs) has them regulated the same way as conventional crops, based on whether there are any negative impacts on the environment or human health.

Currently, the only gene-edited crop approved for sale–as a 'non-novel food'–are mustard greens with less bitterness, produced by Pairwise. Several crops produced using other gene technologies are also approved: for example, the Arctic® non-browning apple cultivar from Okanagan Specialty Fruits, produced using RNA interference, gained approval for sale in 2015.

Meantime Simplot's non-browning potato, also produced with RNA interference, was approved in 2016 but has been put on hold for release.

Japanese go GABA

Japan is also proving something of a pioneer in gene-edited food products as it strives to try and reduce its reliance upon bulk commodity crop imports and develop a better rate of self-sufficiency in its food supply model. It has approved the introduction of four food products with gene editing technology embedded in them.

Two are fish varieties, while the third is the GABA-enriched tomato from Japanese biotech company Sanatech. The fourth is a waxy corn variety.

Approved two years ago, the Sicilian Rouge tomato has been edited to contain elevated amounts of γ-aminobutyric acid, or GABA, and was the first commercially gene-edited food crop to gain approval globally. The amount of GABA in the tomato is elevated to four times the average by using gene editing to disable a gene that suppressed GABA content.

GABA is known to help lower blood pressure and increase relaxation, although the company has been careful not to make a direct clinical claim around the tomatoes as a 'functional food'.

Some clever marketing to home gardeners helped gain traction for the tomato, building a community invested in its success within their own home gardens from an early stage.

Japanese GABA tomatoes on vine
Copyright Sanatech Life Science Co. Ltd

Born in the USA

The United States has been somewhat of a poster child for developing and growing genetically modified crops, with more than 70 million hectares of mostly row crops grown across the nation. NBTs, particularly CRISPR gene editing, have also captured the attention of scientists and producers.

Currently, three gene-edited crops have been approved for sale in the USA. Consumers can purchase gene-edited non-browning lettuce seed from GreenVenus™ to grow at home. The company is also using CRISPR gene editing to develop grapes with natural preservation properties, and a non-browning avocado.

Pairwise launched Conscious™ Greens mustard greens to US consumers in 2023 to test consumer sentiment, exiting the market in early 2024 to concentrate on its core business of R&D.

Pairwise chief operating office Ian Miller said the company sold off Conscious™ Greens to Bayer, soon recognising it was a gene tech company, not a salad distribution operation.

"But our survey work when we launched Conscious™ Greens showed consumers were very happy with the product and were not concerned over the use of gene editing to create it."

Pairwise is now working on blackberries with soft seeds and pit-less cherries. With gene editing technology, Miller likens the company to a computer chip company whose tech is installed in different brands of laptops.

The company has a licensing agreement with UK-based fruit company Tropic to incorporate its gene tech in tropical fruit crops.

Meantime several tomatoes, including Japan's high-GABA tomatoes, and a number of gene-edited row crops, have been approved for commercialisation in the USA.

Crops produced by other gene technologies are also entering the market, with the first non-browning Arctic® apple developed in Canada gaining approval in 2015 and the latest variety, Arctic® Gala, approved in October 2024. More than 500 hectares of Arctic apple trees are planted in Washington State.

A merger of Cibus and Calyxt in 2023 saw the new Cibus parent company gain access to three crops, designated by the USDA as non-regulated, developed by Calyxt using TALENS technology–another form of gene editing–to add to their portfolio.

Gene editing policy developments around the world

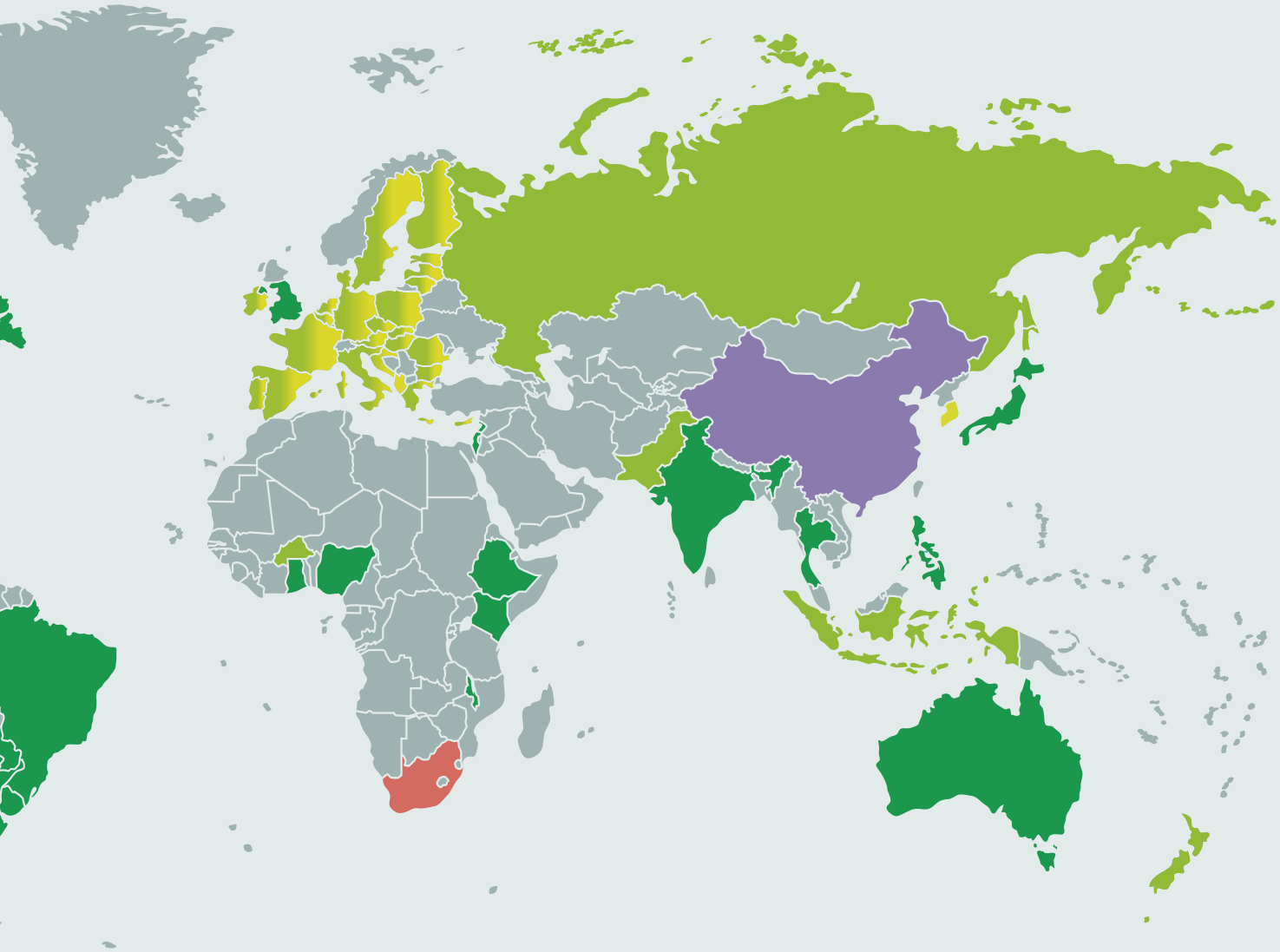
A global liberation

In China, regulations enabling genetically modified food research and production are well embedded. In 2015 food safety rules allowed production of such foods, subject to labelling. The latest Chinese work includes developing a healthy fat oleic acid soybean as its first approved gene-edited crop.

India has used CRISPR technology to biofortify bananas to boost vitamin A in a 'super banana', and globally there are assorted 'long life' gene-edited vegetables under application, including avocados and lettuce.

In Australia, researchers have enjoyed relatively liberal gene technology regulations for almost a quarter of a century through its Gene Technology Act.

While still not entirely mapped out, it appears likely New Zealand will take a similar pathway, with a gene technology regulator office overseeing approvals of research and commercial release.



- Differentiation from GMO regulations (at least by one agency/authority)
- Draft proposal to differentiate from GMO regulations (at least by one agency/authority)
- Draft proposal where products considered GMOs but with simplified assessment procedure/requirements
- Products considered GMOs but with simplified assessment procedure/ requirements
- All products considered GMOs

Information courtesy of the International Seed Federation as at February 2025

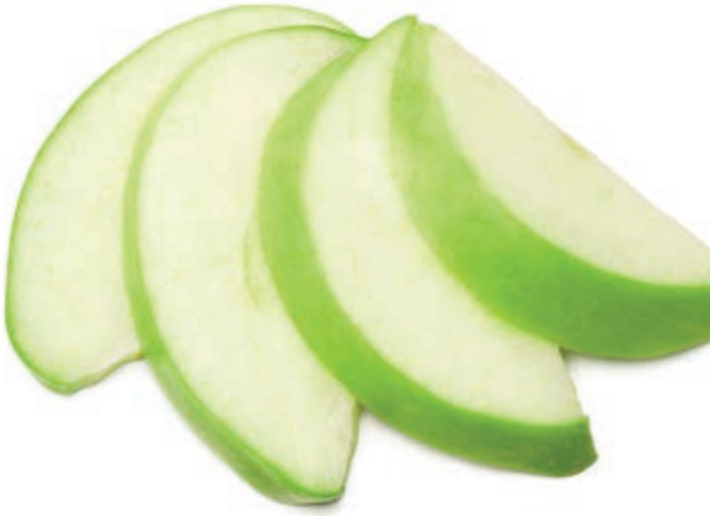
Arctic® apples are grown in Washington State, USA. Current varieties are genetically modified, but developers Okanagan Specialty Fruits are investigating the potential for gene editing.

Fresh as apples

Canadian company Okanagan was responsible for releasing the first and so far only commercially available genetically engineered apple to market, the Arctic® Advantage in 2017. It began from the desire of its founders Neal and Louisa Carter to reduce fruit wastage–as high as 40% for apples–and lift apple consumption.

They used RNA interference gene technology (a transgenic approach) to remove the browning enzyme from the apple's DNA, ensuring it can keep for longer once sliced.

Okanagan's business development vice president Sarah Evanega says a slide in apple consumption over the years reflects general fresh fruit consumption decline, particularly in children.



"Children are 70% more likely to consume sliced fruit than a whole fruit item. We only retail sliced apples, slicing to order and shipping with a 28-day shelf life, the longest of any apple on the market."

Being able to slice and sell not only appeals to consumers, but also cuts the shipping weight down by about 20%, with the unwanted cores being used for cattle feed. The non-browning characteristic also makes for a high-quality cider that has a crisper, clean taste thanks to the apple juice holding its freshness longer.

Evanega is excited about the prospects the next generation of gene-editing tech will bring to the plant crop sector.

"We used RNAi technology for the original apple but today it's CRISPR techniques. It used to be you only saw genetic modification done on row crops like soy and corn.

"So far we have only really seen the Arctic® apple, a purple tomato, a papaya out of Hawaii and a potato, [but] far too few crops.

"But with gene editing there are so many more crops out there that have significant value for middle-income countries that may not be as globally traded but are still important. Gene-editing technology means we have the opportunity to take that much further, and extend the traits we include."

She believes the decision to modify a crop no longer has to be a binary one that is either 'farmer friendly' in terms of improving management of the crop, or 'consumer friendly', such as an eating trait.

"We can now combine what both the consumer and grower need and make agriculture far more sustainable as a result."

Overall, the number of gene-edited plants offering consumers some benefit in taste or function remains relatively light.

Plant & Food Research scientist Dr Revel Drummond says he doesn't expect to see a wave of foreign companies pushing to propagate their gene-edited crops in New Zealand once regulations change, given the size of the market.

"I think we're more likely to see food products or ingredients being imported, and small companies like

> Children are 70% more likely to consume sliced fruit than a whole fruit item.

Daisy Lab, for example, in New Zealand producing ingredients with fermentation technology using gene-edited microorganisms."

He does see the value in having gene-edited, consumer-facing traits that will increase the rate of acceptance of the technology.

"Pairwise's Conscious™ Greens leafy greens, for example, make those greens more edible. That engages consumers, and once engaged, they are usually pretty accepting of the technology."

Gene technology path a fraught one

The interplay between the cost of developing new types of crops using gene technologies and their commercial uptake plays an integral part in determining which are likely to come to market first.

Since the 1990s most commercial efforts involving genetically engineered plants have focused on high-volume crops grown in broadacre style, including corn, cotton, wheat and canola, with the main focus of the tech being on making those crops either more productive, more harvestable, or both.

As a result, BT corn and cotton crops - with a gene from the bacterium *Bacillus thuringiensis* that makes them resistant to some insect pests; 'Roundup® Ready' glyphosate-resistant crops and drought-resistant corn have underscored efforts to date.

Nutritionally enhanced plants, like high-nutrition tomatoes, have faced a tougher road, but prospects are increasingly positive as technology costs fall and techniques improve, alongside consumer acceptance of it.

More produce choice on way

Australia's gene technology regulator Dr Raj Bhula has noted how much of the gene-editing technology has kicked off with a focus primarily upon making crops more productive or manageable.

However, she is also confident that as the technology evolves, the pace and focus on food types will gain momentum.

Okanagan's Evanega is watching New Zealand's regulatory moves with interest. She says having a positive, enabling environment for public and private research where the focus is upon outcomes, rather than processes, is vital.

"Gene technology is no longer an issue for consumers in terms of concern.

"Often, they don't know a lot about it, but when it is explained to them, they are overwhelmingly in favour of it, particularly if the technology is offering a personal nutrition or use benefit. They appreciate the sustainability benefits it can deliver, such as lower pesticide use or lower water use."

FEATURE

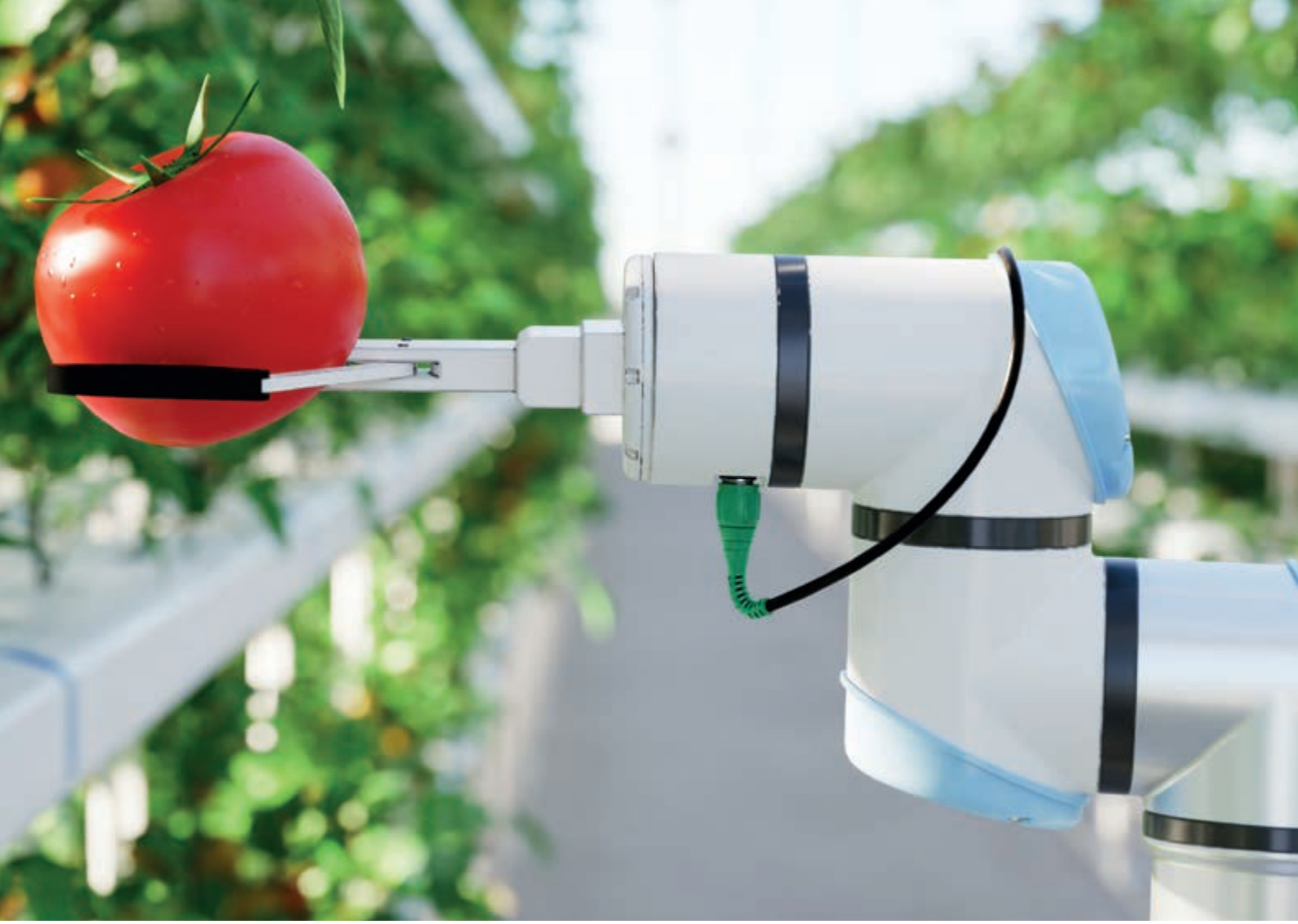
Smartening up food systems

BY MATT PHILP

An autonomous vehicle trundles down orchard rows. Fixed cameras whirr below the canopy, and in a packing shed a robotic arm sorts fruit on a conveyor belt, its touch as gentle as any grading line veteran. This is not a description of farming's next frontier, it's the here-and-now of food production in the 2020s.

Artificial intelligence is already deployed on our farms and orchards, part of a reimagining of the food system aimed at doing more with less, and doing it more sustainably. Driving the shift is a set of challenges that range from the planetary – climate change and population growth – to sector-specific such as labour scarcity in the horticulture industry.

New Zealand is not lagging behind in this evolution. As Agritech NZ boss Brendan O'Connell remarked in a recent interview for the People, Planet, Food podcast, this country's food production sector has a healthy population of trailblazers, not least



because the absence of direct subsidies has instilled a highly professional, pragmatic, commercially driven mindset. “It creates an environment where we’ve seen many firsts happening in New Zealand … a very good environment for both technology adoption and technology creation,” he observed, adding that Kiwi growers are focused on innovations that deliver verifiable on-farm value. “They have a high bar.”

Whether here or overseas, it’s the range of high-tech tools that’s so striking. Robotics is the obvious eye-catching example. In New Zealand, Tauranga-based firm Robotics Plus has developed an autonomous, multi-use vehicle platform for a variety of crop tasks, as well as the Āporo Fruit Packer, a robotic solution designed to improve the reliability and accuracy of packing. In the United States, a venture called advanced.farm is deploying robotics to harvest apples in Washington State and strawberries in California. In the latter case, the company claims its technology is five times more productive than a human harvester.

Less glamorous, perhaps, but just as significant is a wave of packhouse automation epitomised by New Zealand-born firm Compac, which uses cameras, sensing and machine learning to power high-speed fruit sorting. And sitting in behind all this are software packages and management tools that turn the torrents of information being collected on farms into actionable insights. Kiwi outfit Integrape, for example, has developed a solution that pulls together all a vineyard operation’s salient data, from tracking diseases to fertiliser application to yield estimates, allowing growers to gain a better handle on historical trends, variability and problem areas.

> “This country’s food production sector has a healthy population of trailblazers, not least because the absence of direct subsidies has instilled a highly professional, pragmatic, commercially driven mindset.

New Zealand fresh produce grower and distributor T&G Global hasn’t dragged its feet. “We’re doing a lot of work at the intake end of our packhouses, where we have cameras to interpret the fruit in real-time and determine the best way to maximise and pack each apple. This happens at 3,500 fruit per minute,” says Craig Kenny, the company’s national head of postharvest. “We’re also working on the grading side.

T&G Global is using AI to analyse and monitor key attributes of ENVY™ apples as they are picked.

We upgraded our software in 2024 in Nelson and Hawke's Bay with a mini-computer that uses AI in fruit grading. It's looking at colour, weight, defects, and also measuring the internal qualities of an apple, and grading the fruit appropriately for each market in real-time. Every time something is processed, it's learning so that it can dial in more and more accurately."

In 2023, T&G Global opened a state-of-the-art packhouse in Hawke's Bay that epitomises what postharvest technology can deliver.

T&G Global's new packhouse in Hawke's Bay incorporates AI and other new technologies, improving efficiency.

Commissioned as a response to growing global demand, the new facility deploys AI and other innovations from the wet infeed area to robotic fruit packers and palletisers. Craig says the new packhouse uses half the labour to process twice as many fruit and with reduced errors, minimising fruit wastage and keeping a lid on rising costs. But it's no silver bullet, and the company will continue to invest in innovation. "Typically in the past you might have bought the flashest bit of kit and sat on it for 15 years. A lot of what we do now is to partner with suppliers to maintain R&D for continual improvement."

One example is an AI-powered quality control platform called Clarifruit. The solution includes a smartphone app for inspectors that uses proprietary 'computer vision' technology, plus a management and analytics dashboard. Take a photo of a box of 'Scilate'/ENVY™ apples and Clarifruit's machine learning will analyse the colour, size and other attributes, while the dashboard gives an overview of every inspection's salient data, including date and time and GPS location. After a successful trial in New Zealand, T&G is about to deploy Clarifruit across its global growing operations, and, eventually, across the company's entire supply chain, from grower to customer.

"T&G is heavily focused on premium apple brands 'Scifresh'/JAZZ™ and ENVY™, and with Clarifruit and AI we're able to effectively manage our brand standards, ensuring quality and consistency globally," says Project Lead for Global Quality Richard Iredale. "It's going to take away subjectivity."

New Zealand-born Compac, acquired by TOMRA in 2016, use cameras and machine learning for high-speed fruit sorting.

A Burro robot moves through a vineyard taking photos of vines for analysis by VinEye for detection of Grapevine Leafroll Disease.

Secondary benefits include reduced waste and fewer claims, adds David Booth, T&G's Head of Quality, Market Access and Compliance. "In the fresh produce industry where shelf-life is short, it's about making decisions now. If we have more actionable management insights, then we can make better real-time decisions, leading to reduced costs and waste. Because we don't want to produce fruit that is wasted."

A recurring theme of smart food systems is that the new tools often incorporate science and tech from several collaborating organisations. Take VinEye, for instance, which uses machine learning to detect Grapevine Leafroll Disease (GLD), a significant threat to our $2.4 billion wine export industry and a notoriously difficult disease to detect, requiring trained staff to walk the rows. VinEye instantly analyses photos of vines for signs of GLD infection, and could one day be deployed on robots to offer real-time monitoring that is faster, more accurate and more cost-effective than detection by the human eye.

Plant & Food Research created the VinEye algorithm, and worked with Integrape for three years to develop the tool, which was trialled over 50 hectares in 2024. For the trial, robotics outfit Agri Automation supplied a camera-equipped, self-driving Burro robot to follow vine row paths mapped by Integrape's vineyard mapping tools. Australian agtech outfit Bitwise Agronomy processed and analysed the footage, then fed it to Integrape for interactive visualisation.

Artificial intelligence is the "brains" of VinEye, explains Plant & Food Research project leader Karmun Chooi. "We spent a few years developing the AI to be able to consistently detect the disease, and to see where that brain fits into the digital ecosystem available to the wine industry," she says, adding that the goal is "to create something that's just as good at detection as a human expert, and probably has less internal bias."

The 2024 trial demonstrated that VinEye could be scaled-up from a hand-held mobile app to an autonomous solution. But it wasn't perfect, and the next step will be to stage a second trial in 2025 to fine-tune how VinEye can fit into growers' daily schedules. In addition, Plant & Food Research plans to develop an algorithm to detect grape vine trunk disease, a fungal affliction that already costs the wine industry millions

every year and will only grow more burdensome as a result of climate change.

VinEye is only one example of how AI could be deployed to meet such challenges and growing sustainability demands. “It’s not just about helping people manage for disease, but generally managing their crops,” says Karmun. “Once we get better at understanding the systems, for instance, we could do more precision spraying and reduce the amount of chemicals going out there. And it applies beyond production to the entire value chain. In the case of fresh fruit, we might become better at predicting the best time to harvest, which will help logistically postharvest, and at knowing the best time to ship the fruit. There are many efficiencies you can achieve with AI.”

Zespri’s use of artificial intelligence is a case in point. The kiwifruit marketer adopted machine learning and AI in 2022 to estimate the national supply of kiwifruit, according to Peter McHannigan, Zespri Innovation Manager – Future Technologies. “We work closely with growers and our industry partners to deliver the best fruit to market, and accurate crop estimates are essential to optimise that outcome and return more value to growers,” he says, adding that for the recent kiwifruit season Zespri employed AI to create a official reference supply estimate. “The benefits are that we can provide a data-driven estimate earlier than traditional approaches that rely on imaging fruit on orchard (November as opposed to February), and with more than 96% accuracy in terms of trays per hectare for our Zespri™ SunGold™ and Green™ cultivars, as well as for organics.”

> “The benefits are that we can provide a data-driven estimate earlier than traditional approaches that rely on imaging fruit on orchard

“Another area we are exploring is using machine learning and AI is to understand the impact of climate change on crop yields over the next 10 years. We delivered a proof-of-concept earlier this year where we modelled the impact of the long-term effects of climate change on conventional SunGold and Green kiwifruit. We are now considering extending this modelling work to cover organic growing methods and extreme weather events.”

Zespri are using AI and machine learning to predict harvests earlier as well as plan for changing climates

Protecting indigenous knowledge

BY VERONIKA MEDUNA

Around the world, research is increasingly drawing on the centuries of experience held by indigenous cultures. Veronika Meduna explores how scientists and indigenous communities are finding ways to weave together their different perspectives.

By the time an international group of scientists led by Harvard University published the draft genome of the little bush moa last year, they had already deposited the sequence data in an open-access database run by the US National Center for Biotechnology Information.

Data produced from non-human genomic studies are routinely shared on open-data repositories for others to use in future research, and this is often mandated by funders.

But the sequencing was based on ancient DNA from a fossil bone found in New Zealand's South Island, and acquired by the Royal Ontario Museum. It wasn't until later, during a conference meeting with New Zealand researchers, that the team recognised the significance to Māori as kaitiaki (guardians) of these ancestral treasures, and deposited the data in the Aotearoa Genomic Data Repository, a database that controls access and upholds indigenous data governance.

This example illustrates the challenges indigenous groups worldwide face when they try to exert sovereignty over relevant genomic data, says Amanda Black, the director of Bioprotection Aotearoa at Lincoln University, who has iwi affiliations with Tūhoe, Whakatōhea and Te Whānau ā Apanui. "They were trying to do the right thing in retrospect, but by that point it becomes a token gesture."

> "While physical samples can't be reproduced, it's different for data. Once data are shared, they are out there and you can't pull them back.

While there's growing support for the rematriation (returning to the land of your ancestry) of human remains and artefacts into the care of indigenous communities from which they were originally taken, this doesn't yet apply to non-human items. Nor is it a given that international researchers seek consent from indigenous communities for whom such items may be important. Many are considered kin or sacred–as moa is to Māori–because of the wider ecological relationships indigenous people regard as key to cultural identity, Black says.

There is an added challenge when it comes to the sets of data gleaned from such items. "While physical samples can't be reproduced, it's different for data. Once data are shared, they are out there and you can't pull them back."

Restoring the sacred

But there are many exciting initiatives underway to uphold data sovereignty, including several projects underway as part of a partnership agreement between Rangitāne o Manawatū and Plant & Food Research in New Zealand.

This includes the restoration of the critically endangered native swamp maire. A tree once plentiful in the Manawatū when the region was still swamp land, it had declined to just 29 individuals in the iwi's rohe (territory), says Wayne Blissett.

Swamp maire is culturally significant to Māori for its use in rongoā (traditional healing) and as an air freshener. Its timber is also favoured for weapons. But to start a restoration project, the iwi (tribe) needed to know whether the remaining trees had enough genetic diversity to propagate seedlings from them.

Genome sequencing was carried out as part of a broader project to investigate genetic diversity of swamp maire nationwide, and in recognition of the importance of mana whenua (the rights of people with a connection to the land) when working with taonga species, Rangitāne o Manawatū were invited to name the genome: ngā hua o te ia whenua. The iwi became the first indigenous group to do so.

"The iwi supported the mapping of the genome and appreciated the naming as part of an authentic partnership," Blissett says. "When we talk about benefit sharing, it's often seen as a monetary concept, but this was seen as a real benefit by the iwi in regard to being able to express kaitiakitanga (guardianship)."

To guide their research endeavours and partnerships, Rangitāne o Manawatū has adopted best-practice principles from the Waitangi Tribunal's WAI262 claim, which asserts Māori sovereignty over taonga species (endemic flora and fauna of significance in traditional and contemporary contexts). These principles ask scientists, Māori or non-Māori, to develop respectful relationships with tangata whenua (the people of the land) and to move to co-leadership and co-development of all aspects of a planned science project. They also call for benefit sharing and reciprocal capacity building.

In the day-to-day context of the swamp maire conservation project, this means that the iwi provides cultural confidence programmes for scientists, and iwi representatives in turn learn research techniques, in this case propagation and ecosystem monitoring. Other projects under this partnership, such as an exploration of karaka kernels as a commercial crop, build capacity in a range of other skills.

Young swamp maire plants are propagated for conservation purposes with the katiakikanga (guardiandship) of Rangitāne o Manawatū.

Pictured Maui Hudson (Whakatōhea, Ngāruahine, Te Māhurehure), the director of the Te Kotahi Research Institute at the University of Waikato and a founding member of the Māori Data Sovereignty Network and the Global Indigenous Data Alliance.

As part of the relationship-building process, Rangitāne o Manawatū and Plant & Food Research co-developed the Te Aniwaniwa framework of shared accountability, which provides a path for other iwi, Blissett says. “The challenge with iwi is that we’re all at different stages of capacity, capability and focus areas and, from my perspective, the process we’ve gone through can be shared as a way of reaching a partnership. Every iwi would want to adjust that to what works best in their rohe and with their strengths.”

Most importantly, any relationship must continue to evolve. “Best practice is to be authentic from the beginning,” Blissett says. “And it’s OK to disagree. Sometimes people try too hard to make it all perfect, and it never is. We put that as our shared commitment that we would learn as we went and adapt as we needed to, but that this would be through discussion and shared decision-making, both changing together.”

> “When we talk about benefit sharing, it’s often seen as a monetary concept, but this was seen as a real benefit by the iwi in regard to being able to express kaitiakitanga (guardianship)

CARE for indigenous data

The need for better agreements and protocols for data governance developed in tandem with the rise in technologies able to produce massive datasets, such as genomics and eDNA, and more opportunities for secondary uses of these data, says Maui Hudson (Whakatōhea, Ngāruahine, Te Māhurehure), the director of the Te Kotahi Research Institute at the University of Waikato and a founding member of the Māori Data Sovereignty Network and the Global Indigenous Data Alliance.

An early approach focused on data characteristics and management, and developed a set of principles known as FAIR–findable, accessible, interoperable and reusable. It was guided by the believe that data produced through publicly funded research should be transparent and accessible. But it raised concerns among indigenous communities about secondary data use and limited opportunities for benefit sharing, creating a tension between the need to protect indigenous rights and interests (including traditional knowledge) and supporting open data, machine learning and big-data initiatives.

From this came more people– and purpose-oriented principles known as CARE, which stands for collective benefit, authority to control, responsibility and ethics. "The CARE principles really arose from a coming together of people thinking about what was needed in the conversations around open science and open data, which remain prominent," Hudson says. "Open science created greater use [of data], but also greater misuse or appropriation. It didn't require any kind of relationship to enable it."

Hudson says the CARE principles are complementary to the FAIR approach because data characteristics remain an important foundation, but they enable more nuanced discussions about who collects data, how they are stored and reused, and who benefits from the research. Open data access remains the aspirational goal, Hudson says, and indigenous data sovereignty is no different from other generally accepted exceptions such as commercial sensitivity and privacy protections. It's about what rights or interests indigenous communities might have "in this evolving data landscape, how data are used to generate value and how that value can be distributed", he says.

Together with fellow Waikato researcher Haki Tuaupiki (Waikato, Ngāti Tūwharetoa), Hudson has been invited to join investigators at the new US$30 million Center for Braiding Indigenous Knowledges and Science at the University of Massachusetts Amherst in the USA. The centre's goal is to interweave the wisdom of indigenous knowledge with cutting–edge scientific innovation to tackle pressing issues, including climate-change impacts on ecosystems and irreplaceable archaeological sites. "Faced with the profound challenges of a rapidly changing environment, society needs other ways of knowing, to illuminate a different way forward," Robin Kimmerer, one of the centre's leaders wrote in an editorial in Science last year. "Thanks to the leadership of indigenous scholars and allied collaborators, indigenous knowledge is receiving long-overdue recognition for its potential to provide solutions for the mutual thriving of lands and cultures."

The CARE principles have also been adopted by other organisations, including in UNESCO's recommendations on open science.

> **C.A.R.E. PRINCIPLES**
> - Collective benefit
> - Authority to control,
> - Responsibility
> - Ethics

> Globally, Canadian First Nations are seen as flag bearers of indigenous data sovereignty

Plant & Food Research and Rangitāne o Manawatū work together to understand and incorporate Māori culture in research.

Protecting indigenous data on a global scale

Globally, Canadian First Nations are seen as flag bearers of indigenous data sovereignty. The First Nations Principles (OCAP, for ownership, control, access and possession) have asserted rights to control data collection and how information can be used for two decades. Canada is currently developing a strategic plan to co-develop research and training with First Nations peoples to contribute to reconciliation.

Similar codes have been developed in Australia and the USA, sharing common features of indigenous self-determination, an emphasis on collective data rights and recognition of data as a cultural resource.

"Data are taonga", says Linley Jesson, a co-leader of Plant & Food Research's Data Science group.

Her work is focused on developing core principles for all New Zealand's Crown Research Institutes (CRIs). "We're coming from a place where we haven't consulted historically," she says. "But we now have principles for working with Māori, which include respecting data as taonga and taking appropriate care".

The work has been endorsed by Te Ara Pūtaiao, a group of Māori senior managers across all CRIs, and is a step towards fulfilling international obligations under the UN Declaration of the Rights of Indigenous Peoples and the Nagoya Protocol on access to genetic resources and fair benefit sharing. Even though the current coalition government is not planning to ratify the declaration, and New Zealand has not signed the protocol, ethically these obligations still apply, Jesson says.

In 2023, Te Kāhui Raraunga, an iwi-led group of Māori data experts, released a Māori data governance model with recommendations for research organisations. Its eight pou (pillars) of good data governance cover workplace development and infrastructure, data acquisition and sharing, reuse and protection. Jesson says to achieve genuine co-development, collaborations have to start early, even before funding applications, and should grant decision-making authority to iwi partners right through to publication– even if that means holding publication until consent is given.

Hudson also wants to see indigenous research partners acknowledged in publications so anyone interested in accessing the data knows who to consult. "This happens automatically for the research organisations because the metadata holds that information, but it generally doesn't for community [research] partners. We're trying to leave more visible signs of communities' interests on the different types of things that emerge from a project, because one of the issues that's arisen with misappropriation of samples is really that they've been used in contexts for which they hadn't been consented."

At the moment there's nothing to prompt scientists interested in following up on published research to engage directly with indigenous communities. But if they are acknowledged and if databases uphold the CARE principles, then people seeking access have to explain why they want the data and how they're hoping to use them. The principles don't necessarily close off access, he says, but they give the power of decision making, adding a layer of sovereignty.

GLOBAL FOOD LEADERS

An interview with Jiunn Shih, Chief Marketing, Innovation & Sustainability Officer, Zespri

Segment talks to Jiunn Shih, who shares his views on food and marketing, the big issues facing food producers, and how his three portfolios – marketing, innovation and sustainability – work together to help multinational kiwifruit marketer Zespri stay relevant for consumers.

Your role covers a wide range of areas – how do marketing, innovation and sustainability meld together in a company like Zespri?
At Zespri, we see all these things through the lens of value creation. Marketing is a function about creating more value, for our growers and for Zespri, through driving and creating demand in the market. It's about justifying the price premium, lifting the willingness of our customers and our consumers to purchase our products. Innovation is also about value creation – developing new solutions that can lift productivity, drive more efficiency, create more resilience across the value chain, develop new products for consumers. Sustainability is more than staying compliant but can be an opportunity for creating more value, a lens by which we can do better as a company, a way of achieving our values and delivering on some of the big challenges and transformations that we need long term. Take plastic packaging, for example. We all know our packaging should be recyclable, compostable or reusable, but that comes at a cost. Value creation is about finding ways to transform our packaging so it can also be more valuable to our customers in ways that can be a win for both sides.

What do you think is the biggest selling point for New Zealand food products overseas?
In some markets, the provenance story of New Zealand has been a strong selling point for many years – the clean, safe, high quality of our products. I think going forward that New Zealand food companies are going to have to evolve beyond that provenance story to maintain a competitive advantage. It's about continuing to invest in innovation and offering better food for people than they can access locally or through other producers. I think New Zealand has all the ingredients to become one of the leading food innovation hubs, with the right level of investment, with collaboration from the entrepreneurial private sector with the research institutes, and with support from the Government.

You're based in Singapore even though you work for a New Zealand company. Does that proximity to key markets provide valuable insights for your role?
I believe you can only do good marketing when you are close to your consumers and customers. While I'm based in Singapore, I'm travelling more than 200 days a year. I want to be close to the markets, understand what consumers are buying, what they're thinking. I need to understand our customers – the retailers and distributors – so I can bring those insights back into our business. Singapore is a really well-connected hub for our key markets. China, Japan, Korea, Central Europe are all a direct flight away.

Are there any new technologies being developed that you think will create a step-change for the food sector?
Even with the birth rate declining, the world population is still going to increase to 10 billion people by 2050. If we maintain the same productivity we're going to have a big gap in terms of being able to feed people, particularly without new

technologies. The changing climate also means that the same level of productivity isn't a given.

With all that in mind, there are three technologies that I think will be game changers for food production. One is controlled environment agriculture – high tech methods of growing plants in controlled environments so you can optimise growing conditions and protect crops from the elements. Gene editing is also an important technology that will become more widespread. Making those precise changes to the DNA of a plant will open up so many possibilities to have better, more nutritious, more resilient and more productive crops. The third technology that I think is really exciting is precision fermentation, allowing much better production of food ingredients that requires either less space or fewer inputs.

What's the key challenge facing the horticulture sector in terms of sustainability?
Climate change.

I think we have grown increasingly more immune to the images of wildfires, hurricanes, floods. They come so often they don't even feel real any more until we feel it ourselves. The horticulture sector is really exposed – you only have to think back to the impacts of Cyclone Gabrielle and the devastation on orchards. What worries me is not the impact of climate change on our crops and the different growing regions in New Zealand, but the volatility. The problem is not the average yield, but the volatility of yields from year to year. That's going to amplify the risks for farmers and growers. Innovation is going to be a survival imperative for the agricultural sector, whether that's more climate tolerant cultivars or alternative growing systems. Now, it's not about holding different sectors responsible for mitigating climate change, it's about building resilience, adapting to climate change and ensuring food security.

Most of your career before Zespri was in fast moving consumer goods (FMCGs) like hair care, cleaning products and processed foods. What are some of the similarities and differences you've noticed between FMCG and fresh food marketing, and which has been the most surprising?
The main difference is the speed, the pace. Fruit is a perishable product that you can't really predict. You can't predict the size of the fruit and what size your crop will be, every season is different. You have to be more agile and flexible. I think that's exciting. When you work in large FMCGs the production, the planning process is all really predictable.

What's interesting to me is that of all the investment that goes behind the marketing of food, almost none of it is for fresh food. I think we're facing a real paradox – food is supposed to be nourishment, but we have so many people with chronic diseases because they're not eating the right food. We know we all need to eat more fresh fruits and vegetables, but less than 20% of people eat five portions a day, which I think is not sufficient anyway. Kiwifruit is one of the most nutrient dense foods in the world, so to work in marketing and innovation for kiwifruit is an incredible privilege. I'm applying my skills for something I think is good for people around the world.

> "Sustainability is more than staying compliant but can be an opportunity for creating more value

Your career has taken you all over the world – what's are some of the strangest and/or most surprising foods you've encountered?
I have a real interest in food; even before I worked for Zespri I used to work with foods. Before I became a vegetarian I ate almost everything – the most unconventional are probably pigs' brains and crickets. One of my favourite foods is something that is a little strange for most people, particularly those who aren't Asian, and that's century egg. It's a preserved egg that is black, it looks and smells rotten but tastes delicious. It is very common across Asia. It is a favourite of mine.

You were born in Taiwan and brought up in Brazil - what's your comfort food, that taste of home you seek out when you're living overseas?
The thing that's common between both places is that they are big fruit producers, and I love fruit! Fruits are my comfort food. When I go to Brazil, I love eating fresh papayas. When I go back to Taiwan, the fruit that feels like home is wax apple. Everywhere else, of course, it's kiwifruit!

PHOTO FEATURE

A dragon's treasure

From Viet Nam to New Zealand, dragon fruit is spreading its wings

PHOTOGRAPHY **BEN LAWRENCE, WARA BULLÔT, ROBERT LAMBERTS & SUZIE NEWMAN**

A ripe dragon fruit still on the cactus. Dragon fruit are the fruit of the pitahaya, a climbing cactus that can grow from 15-20 feet high and can live for as long as two decades. The name of the plant come from its unique appearance – with leather-like skin, and "scales" on the outside of the fruit it was thought to resemble a dragon. The "scales" on the skin are actually modified leaves that act as a protective mechanism for the plant.

IMAGE BY: BEN LAWRENCE

Dragon fruit are a common sight in supermarkets in Asia and growing in popularity overseas. While production is on the rise, the changing climate means that dragon fruit could be grown outside of its normal equatorial regions in more subtropical zones, such as New Zealand's north.

What began as a collaboration in 2000 focused on improving dragon fruit export protocols, a partnership between Vietnamese and New Zealand scientists expanded to include breeding new varieties to enhance productivity. Improved growing techniques, more sustainable postharvest treatments, more efficient export systems and three new disease resistant dragon fruit varieties have come out of this partnership which is transforming the Viet Nam dragon fruit sector.

The collaboration has also provided valuable insights into subtropical fruit production, and has led to the introduction of dragon fruit to New Zealand. As New Zealand's climate warms, growing crops like dragon fruit presents new climate-resilient opportunities for horticulture in subtropical northern regions. Early trials in Northland are showing promise, suggesting that dragon fruit could become a viable new crop for New Zealand, creating employment opportunities and diversifying the agricultural sector.

Mr Tien, a dragon fruit farmer from Mỹ Tho Province, Viet Nam stands in his dragon fruit farm in Viet Nam. Dragon fruit originated from central America but was brought to Southeast Asia in the 19th century by the French. It was first grown commercially in the 1980s. In Viet Nam, currently the largest producer and exporter of dragon fruit globally, is it called "thanh long".

IMAGE BY: WARA BULLÔT

IMAGES ON THIS SPREAD BY BEN LAWRENCE

Sucking pollen from a dragon fruit flower. Breeding a new fruit cultivar requires careful and controlled cross-pollination to ensure that two plants with desired traits are bred to create a new hybrid variety with traits from both parents. This is done through hand pollination like this over multiple generations to create cultivars with the most desired traits.

ABOVE | Two researchers inspect the dragon fruit flowers at dusk at the Kerikeri trial. As they are a climbing cactus, dragon fruit orchards need a support structure to allow them to climb. The T-bar system was developed as a more cost effective system, supporting the cactus and increasing yield while allowing room to spray for pest and disease control.

LEFT | The fruit's "dragon scales" are more evident in the bud stage. Dragon fruit growth hits its peak in the summer season. Dragon fruit flourish in warm climates with plenty of sunlight and well-draining soil, with harvest season in late summer.

The fruit is ready to harvest about a month after flowering and only the flesh inside the fruit is edible. Dragon fruit varieties are red-skinned but can vary in flesh colour, from the more common white flesh through to a dark, appealing red.

IMAGES ON THIS SPREAD BY BEN LAWRENCE

LEFT | Plant & Food Research dragon fruit breeder Satish Kumar inspects young dragon fruit sprouts. From seed, dragon fruit can take up to 5 years to produce fruit. A key characteristic for the breeding programme is tolerance to canker, a highly destructive disease of dragon fruit, killing plants and causing visible damage to fruit.

ABOVE | A bee visits a dragon fruit flower. Dragon fruit flowers are unique in that they open at night and close during the day. Dragon fruit can be naturally pollinated by bats, moths and bees. Once successfully pollinated, the flower will start to shrivel, and the fruit will form from the base of it.

Plant & Food Research orchardist Harry Blunden harvests a ripe dragon fruit. Dragon fruit are low in calories but high in vitamin C, fibre, and antioxidants. The fruit also contain iron and have a high-water content of about 90%, meaning they are a great hydrating fruit. They are known for their potential health benefits, including boosting the immune system and improving digestion.

IMAGE BY BEN LAWRENCE

RIGHT | Scientist Bouche Jacques-Joseph is monitoring dragon fruit cuttings to see if they can grow indoors under controlled environment agriculture conditions. In an indoor facility like this one, factors like light, temperature, humidity, and irrigation are manipulated to establish optimal growing conditions.

IMAGE BY ROBERT LAMBERTS

Mrs and Mr Tien holding home grown dragon fruit from their farm in Viet Nam. Through collaborative research, the livelihoods of the dragon fruit farmers are improving. For over 40 years Mr Tien grew rice. The switch to dragon fruit has provided his family, as well as many Vietnamese growers, a higher value, more sustainable crop with new export markets.

IMAGES ON THIS SPREAD BY WARA BULLÔT

ABOVE | Treating the fruit postharvest. Viet Nam exports dragon fruit to more than 30 countries. Improved export protocols with better control of postharvest pathogens are now used in packhouses across the region. This helps the fruit last longer when travelling overseas, meaning more fruit can be transported by sea which is more sustainable and economical than airfreight.

LEFT | Nguyen Khanh Ngoc, a plant pathologist from Viet Nam's Southern Horticultural Research Institute (SOFRI) examines dragon fruit. Not only is the collaboration helping farmers and exporters, but it is also nurturing Viet Nam's next generation of horticultural scientists. The partnership has supported new research along with new pathology labs and scientists like Mrs Ngoc are committed to both creating and sharing this new knowledge by mentoring young researchers.

The New Premium Fruit Variety Development project was supported from 2013 to 2021 with funding from the New Zealand Ministry of Foreign Affairs and Trade, with additional investment from Plant & Food Research. Plant & Food Research's science team collaborated with SOFRI and the Sub-Institute for Agricultural Engineering and Postharvest Technology (SIAEP) in Viet Nam. In 2023, VentureFruit™, T&G Global's IP management and commercialisation company, joined the collaboration with exclusive global commercialisation rights to the first three varieties from the programme.

Magnificent macadamias

Macadamia nuts are delicious and in demand all over the world for their taste and nutritional benefits. Though one of the hardest nuts to crack, local growers are now poised to "crack" the industry wide open with innovative techniques and sustainable practices.

A growing global market

Macadamia nuts are highly sought after worldwide for their delicious taste and nutritional benefits. Originating from Australia, macadamias have become a staple in global markets, with key producers including Australia, South Africa, and Hawaii. Despite their popularity, macadamias remain one of the hardest nuts to crack, both literally and in terms of industry growth. However, Aotearoa New Zealand is now poised to carve out its place in this expanding market with innovative growing techniques and a focus on organic growing, nutrition, sustainability and community.

New Zealand's macadamia industry

The first macadamia orchards were planted in New Zealand in the 1970s. Since then, the industry has been small scale, focusing on boutique production. Currently, New Zealand imports more macadamia nuts than it produces, relying on imports from Australia and Hawaii. While local growers have successfully cultivated macadamia varieties, local production isn't yet sufficient to sustain a domestic market. New Zealand's fertile soil, favourable climate, and pest-free environment present an opportunity for organic macadamia cultivation. With strategic investment and research, the industry is set for significant growth, offering a promising future for both new and existing growers.

Torere Macadamia Ltd in New Zealand's Bay of Plenty are hoping to expand to 1000 hectares by 2029.

Challenges and opportunities

Historically, New Zealand's macadamia industry has relied heavily on the Beaumont variety, an Australian cultivar which has been challenging to grow here due to its low yield and labour-intensive harvest. Many local growers are now exploring alternative varieties better suited to New Zealand's conditions. In recent years, research and development efforts have focused on improving nut quality, yield, and sustainable farming practices to establish a viable macadamia industry.

Torere Macadamia Limited: Leading the charge

The company at the forefront of reshaping New Zealand's macadamia industry is Torere Macadamia Limited (TML). Founded by Vanessa Hayes in 1983, TML has spent decades researching and developing macadamia varieties tailored to New Zealand's growing conditions. The company has selected nine high-quality varieties that drop naturally from trees in an organic production system.

In 2022 TML with Plant & Food Research secured High Value Nutrition funding to test the nutritional superiority of these macadamia varieties. Preliminary results pointed to higher levels of vitamin C, vitamin B6, and selenium compared to those overseas and additional work is being scoped to validate these early findings. In 2024, TML secured a contract with Air New Zealand to supply its long-haul and business-class flights with Cinnamon Glaze macadamias, marking a major milestone for the company. TML also works with the Riddet Institute to explore new uses for macadamia husks, shells, and leaves with a focus on functional funds including macadamia yoghurt.

The future of New Zealand macadamias

Despite setbacks from COVID-19, extreme weather events, and economic challenges, New Zealand's macadamia industry is steadily advancing. TML is currently six years into a ten-year growth strategy aiming to expand macadamia orchards to 1,000 hectares by 2029, though this goal has now been extended by five years. TML's growing approach is centred on organic sustainability and fostering collective ownership within the industry. A key priority is the development of a grower-owned processing facility in the Eastern Bay of Plenty, alongside initiatives such as grower manuals, product development, and regional collectives to maximize industry benefits. Along with this TML is dedicated to empowering Māori growers and involve them in all levels of the industry. They support new growers by providing training programmes as well as trees from its new 'state of the art' climate-controlled nurseries built with a Recovery loan from MBIE after cyclone Gabriel and operational from April 2025.

> TML's growing approach is centred on organic sustainability and fostering collective ownership within the industry.

Eating well for a healthy menopause.

Menopause is a natural part of life for women, but it also brings hormonal changes that can influence energy levels, bone density, and overall wellbeing. A well-balanced diet rich in protein, dietary fibre, and essential nutrients can help manage symptoms and support long-term health, allowing you to feel balanced, strong, and energised.

Here are six healthy foods to add to your diet:

Dairy products

During menopause, the decline in estrogen levels can increase your risk of fractures. Dairy products, such as milk, yoghurt, and cheese, contain calcium, phosphorus, potassium, magnesium, and vitamins D and K – all essential for bone health. For individuals who cannot tolerate dairy, calcium and vitamin fortified alternatives such as almond milk, soy milk, and fortified plant-based yoghurts can provide similar benefits.

Phytoestrogen-containing foods

Include phytoestrogens in your daily diet. Phytoestrogens are naturally occurring nonsteroidal plant compounds that are similar to estrogen. Evidence from intervention studies suggests that some phytoestrogens have been shown to reduce some symptoms such as hot flushes and sleep disturbances. Good sources of phytoestrogens are fermented soy like miso and tempeh, flaxseeds, nuts, whole grains, apples, celery and alfalfa.

Quality proteins

Adequate protein intake is essential for menopausal women to maintain muscle mass, support bone health, and manage weight. As estrogen levels decrease during menopause, women may experience muscle loss and a decline in bone density, making protein even more crucial. High-quality protein sources, such as lean meats, fish, eggs, legumes, tofu, and dairy products, provide the necessary amino acids for muscle repair and growth. Protein also helps stabilise blood sugar levels and keeps you feeling fuller for longer, which can help manage menopausal weight changes.

Whole grains

Whole grains are high in nutrients, including dietary fibre and B vitamins such as thiamine, niacin, riboflavin, and pantothenic acid. A diet high in whole grains promotes good digestion, heart health, and balanced blood sugar levels. Incorporating whole grains such as oats, quinoa, brown rice, and whole wheat bread can help support overall wellbeing and keep you feeling fuller for longer.

Healthy fats

Healthy fats play a vital role in supporting overall health, especially during menopause. They help balance hormones, reduce inflammation, and support brain and heart health. Including sources of healthy fats such as avocados, extra virgin olive oil, nuts, seeds (like flax and chia), and fatty fish (such as mackerel, salmon, and tuna) can provide essential nutrients that can help manage menopausal symptoms. These fats also support the absorption of fat-soluble vitamins like A, D, E, and K, ensuring that your body receives the nutrients it needs for optimal health during this stage of life.

Fruits and vegetables

Eating a variety of fruit and vegetables during menopause is important, as they provide essential vitamins, minerals, and antioxidants that support overall health. Kiwifruit, berries and citrus fruits provide vitamin C, for immune support and skin health, while magnesium-rich foods like bananas aid in muscle relaxation and mood stability. Phytochemicals in brassica vegetables, such as broccoli, Brussels sprouts, cauliflower and cabbage, help reduce inflammation and balance hormones.

For more information on the nutrient content of these foods and over 2700 commonly prepared and eaten foods in New Zealand, visit New Zealand Food Composition Data at **foodcomposition.co.nz**

Quick facts

All about hops

Hops have been here for over 100 years

Hops were first grown in Aotearoa New Zealand in the Nelson region in 1842 when they were brought over by German settlers. Since then, the Tasman region has become the heart of New Zealand's hop industry today with 95% of New Zealand hops grown there. This region is ideal due to its high sunshine hours, even rainfall throughout the year, rich soil and sheltered land from strong prevailing winds. It wasn't until the 1950s that the New Zealand's hop breeding programme began because of a disease affecting production of the imported American cultivar that was being grown at the time. New Zealand is an excellent location for hops breeding as it is free from many common hops diseases due to strict biosecurity laws.

Fast growing with a short harvesting window

Hops are some of the fastest growing plants in the world, growing up to 30cm a day in peak season. They produce separate male and female plants, and only female hops are used in brewing. However, the hop harvesting window is short. Hop harvest in NZ generally occurs from Late Feb to March. Hops are tested for dry matter and other factors to determine the best harvest window. If hops are picked too early, it can reduce the yield and disrupt the flavour. Later harvested hops are at risk of accelerated oxidation in storage and more prone to diseases and pests.

Hops grow on bines, not vines

Bines are stems that twist clockwise and grow by wrapping around a support structure. These are different to vines which grow using tendrils that latch onto different structures in different directions. While the bines die back in winter, the root system can survive for 20+ years, regrowing each spring.

New Zealand mostly produces New World hops that are distinct in flavour and aroma

Plant & Food Research has bred more than 20 commercial hop varieties. Most of these cultivars are known as New World Hops, called as such because they are grown outside of the traditional European hop-growing regions. New World Hops are known for being less bitter than the traditional or Old World hops, and have more fruity, citrusy and tropical aromas. The most popular New Zealand hops variety is Nelson Sauvin™, released in 2000, known for its white wine characteristics. Other cultivars like Riwaka™, Nectaron® and Motueka™ are highly sought overseas due to their unique flavours. Together cultivars Nelson Sauvin™ and Motueka™ make up nearly 50% of the annual crop.

Around 95% of the commercial industry are Plant & Food Research-bred cultivars

Most of these cultivars are triploid hops. This means they have three sets of chromosomes instead of the usual two. This makes them seedless, and high yielding of alpha acids and essential oils, which leads to better flavours and brewing conditions; they are a cleaner beer meaning they're without the risk of seed contamination, they're more resistant to disease, they are less bitter, and they have higher levels of fruity, citrusy and tropical aromas. As they don't have seeds, they are sterile, so they are created using a controlled breeding process that involves crossing diploid (2n) and tetraploid (4n) parents.

An important primary industry for New Zealand

New Zealand's hop industry exports to over 20 countries, with key markets being the USA, UK, Australia and Asia. Brewing is a big industry in New Zealand with it accounting for 0.9% of New Zealand's national GDP. This industry also supports about 1.3% of total national employment and over 60% of breweries are involved in tourism. The New Zealand hops industry is working towards full sustainability such as organic and regenerative farming practices. The New Zealand hops industry is working towards full sustainability such as organic and regenerative farming practices.

INSIDE SLICE

At Plant & Food Research, we believe science can create a better future.

By finding smarter, greener options today, we're helping secure the world we want to live in tomorrow. With our partners, we use world-leading science to improve the way they grow, fish, harvest and share food.

A smart green future. Together.

Plant & Food™ Research
Rangahau Ahumāra Kai

A smart green future. Together.

Every day we have around 1000 people working across Aotearoa New Zealand and the world to help deliver healthy foods from the world's most sustainable systems. Here's how they are contributing to improving the sustainability of Plant & Food Research.

"I engage with many aspects of the institute and my colleagues to improve our performance in accordance with the science based Future Fit Business Benchmark. The result is a blend of activity in areas such emissions reductions, improving energy efficiency, and assisting colleagues to become more sustainable with their activities.

STEPHEN WALLACE – LINCOLN
Sustainability Manager

I am contributing to improving the sustainability of Plant & Food Research by actively encouraging my colleagues to recycle and reduce waste. As a site in Clyde, we volunteer time to donate excess fruit to local organisations, which not only benefits those in need but also improves sustainability by reducing the amount of fresh waste on site.

TIFF DA SILVA – CLYDE
Research Associate,
Fruit Crops Physiology

I'm helping to improve our company's sustainability by starting a small eco-challenge for staff, like turning off lights, computers, and AC units when not in use. I also set up a recycling area and worked on better waste management around the site. These simple changes make a big difference in reducing our environmental impact.

KRISTINA BRECKO – KERIKERI
Research Associate,
Fruit Crops Physiology

At the Lincoln site we have organised two native planting days to enhance the local biodiversity on site. We planted eco-sourced native plants that could have been grown in the area pre-European settlement. Additionally, we have improved waste management systems, ensuring more materials are diverted from landfills.

JOSIE DAWBER – LINCOLN
IP Manager,
Plant Varieties

Nicola Park and I are leading monthly meetings of a HB sustainability group, which we founded. In these meetings we organise site sustainability activities, such as our annual cycle way clean up when we pick up all rubbish on the bike track surrounding our Plant & Food Research site, and all recyclables are cleaned and recycled. We have also organised recycling stations on site, so all recyclables can be easily recycled, and we have battery recharging stations. We also work together with the Tono group when organising planting days and plant native plants in our Matariki garden.

REINY SCHEPER – HAWKE'S BAY
Senior Scientist,
Innovative Plant Pathology

I am involved in Plant & Food Research's My Green Lab pilot programme. This focuses on looking at how, as researchers, we can have a lighter environmental footprint in the lab -covering everything from waste reduction and recycling to water and electricity efficiency. I'm keen to help identify new approaches and share our findings with other colleagues. Outside of the lab, staff at our Blenheim Research Centre have been propagating native plants to restore the Ōpaoa River area that borders our site.

CLAIRE GROSE – MARLBOROUGH
Research Technologist,
Viticulture & Oenology

Improving sustainability at a company takes teamwork, and I'm proud to be a part of a large team at Te Puke site who are working together to identify areas where we can improve our sustainable practices. Regular data collection by our team is helping us track progress, especially in improving waste management and utilising recycling streams. One area we can contribute to significantly here is supporting domestic food security by rescuing our surplus kiwifruit that would otherwise go to waste and donating it to local community groups.

KELLY DAVIS – TE PUKE
Research Associate,
Fruit Crops Physiology

Our Strategy

The talent, vision & commitment of our people

Our Core Purpose

Enhance the value and productivity of New Zealand's horticultural, arable, seafood, and food and beverage industries to contribute to economic growth and the environmental and social prosperity of New Zealand

A smart green future. Together.

At Plant & Food Research, we believe science can create a better future. By finding smarter, greener options today, we're helping secure the world we want to live in tomorrow.

Our preferred future

- Focus on big challenges
- Recognised for creating impact that matters
- Demonstrate and celebrate aspiration
- A partner of choice for Māori
- Build freedom to make choices

Impact domains

Sustainable ecosystems
Balancing food production needs with environmental imperatives

Climate resilience
Ensuring food security in a more volatile world

Smart food systems
Embedding digital and technological innovation across value chains

Healthy foods
Creating healthy foods that consumers love and value

Research focus areas

- New plant cultivars
- Plant production systems
- Fresh food quality within supply chains
- Biosecurity, bioprotection and biodiversity
- Food functionality
- Ocean-based aquaculture

OUR FOUNDATION

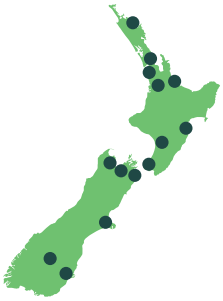
- Great people
- Living our values
- Science excellence and connection to Mātauranga
- Commercial excellence
- Strong relationships

THE NUMBERS 2023/24

942
Total staff

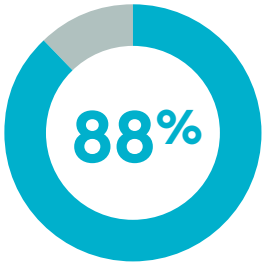
14 New Zealand sites (plus representatives in Australia & the USA)

421 Hectares research farms



Science publications

287
Peer-reviewed publications



Publications co-authored with collaborators

Received in the past 5 years

4
Commercialisation awards

24
Industry awards

33
Research awards

Intellectual assets

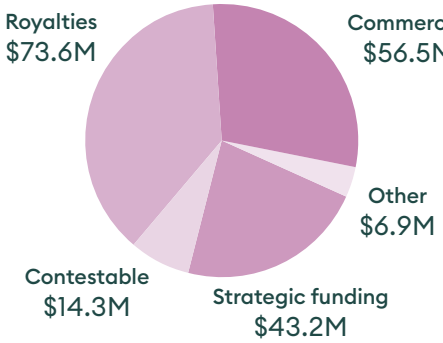
20 Patents granted

8 Plant Variety Rights granted

Revenue

$194.4M
Total revenue

Our activities are funded through direct commercial research for our customers, the reinvestment of royalties and the New Zealand Government's investment in science.



Strategic funding
Government investment allocated directly to each CRI

Contestable
Government investment allocated through competitive bidding

Royalties
Commercial return from plant varieties and IP

Commercial
Direct investment by customers

Other
All other income sources

For the year ending 30 June 2024

Talking sustainability at Plant & Food Research

Sustainability Q&A with Roger Robson-Williams

Chief Sustainability Officer

Q What is your sustainability vision for Plant & Food Research?

A| That concern for the prosperity of future generations informs everything we do. Sustainability isn't about saving the planet. It's about ensuring that future generations of humans have the chance to prosper. As a science-based organisation we understand the implications of exceeding the safe limits of our planet's life supporting systems, and we can take a longer-term view than many businesses can regarding what needs to be done to restore it to a stable state.

Q What do you see as Plant & Food Research's role in addressing sustainability issues in Aotearoa New Zealand?

A| We have several roles to play in helping build a prosperous future for all in Aotearoa New Zealand. Firstly, to deliver science that tackles the most pressing sustainability issues relating to sectors we support. Secondly, through the way we do our science, to show what it means to be serious about addressing our own impacts on people and planet. And thirdly, to share insights with our partners and customers about emerging sustainability challenges and opportunities in Aotearoa and globally.

Q How is a culture of sustainability being fostered in Plant & Food Research?

A| Making progress towards greater sustainability is about changing mindsets and behaviours. We need to support, encourage and grow that grass roots commitment by providing time, money and a clear set of priorities to work on together. We also need to work hard to bring consideration of the prosperity of future generations into every aspect of our planning and decision making. This top-down and bottom-up 'pincer' action will help lock in a strong culture of sustainability throughout the organisation.

Q How is Plant & Food Research defining and measuring its success in improving sustainability?

A| We're using the Future-Fit Business Benchmark. It's a science-based framework that enables organisations to understand the impacts they have on people and planet and to identify tangible ways to become more sustainable. We've been tracking our progress against the Benchmark's 23 'do no harm' goals since 2019 and we're making progress on many of them. We've also been using the Benchmark's 'positive pursuits' to describe the positive impact of the science we're doing that helps others be more sustainable.

Q Is there something in Plant & Food Research's sustainability journey that you're particularly proud of?

A| It's critically important to us to minimise any harm that might arise from the way we do our science. We've set ourselves a target to reduce greenhouse gas emissions, we're working hard to reduce waste, and we're doing a lot to create an inclusive and equitable work environment. But we create the greatest overall positive impact through our science and I'm proud of that.

Q What's one thing you personally do to live a more sustainable life?

A| I try to ask myself who prospers from the decisions I make about how to live my life? This (imperfectly) informs my food choices (mainly plant-based), my approach to personal transport (using public transport or EVs whenever possible), my use of energy (aiming for efficiency, renewability and using less rather than more). It also influences how I spend my time at work and at home (growing food, fibre and fuel, and regenerating native bush), how I spend my money (avoiding single use, poor quality, non-repairable, unethically produced, and frankly unnecessary items), and how I invest my savings (seeking alignment between my values and those of any businesses that my money is invested in). The day-to-day choices we make about how to live our lives are important but insufficient on their own. I'm constantly on the lookout for more ways to live sustainably.

Sustainability Q&A with Mark Piper

Chief Executive Officer

Q What is your sustainability vision for Plant & Food Research?

A| Plant & Food Research and the new bioeconomy public research organization when it comes into being, has a huge role to play in Aotearoa, New Zealand around all tiers of sustainability. Currently in our strategy we have two impact domains that focus heavily on sustainability – Sustainable Ecosystems and Climate Resilience. My vision is that our research programme continues that focus into the future and keeps evaluating what's working and what isn't. We need to continually look if we are doing things in the best way. Repeatedly thinking around how we continue to improve every day, and what we're doing on our sites and in our business is critical. And that should always be our view on it.

Q What do you see as Plant & Food Research's role in addressing sustainability issues in Aotearoa New Zealand?

A| I think we need to lead by example. We have a strategy that has sustainability built into it, and shapes how we do our research. Our individual sites are important in how we address sustainability. They coordinate site-led initiatives to address sustainability challenges, and they champion taking individual ownership of their own workplace. I also think the new bioeconomy public research organisation is an amazing opportunity to continue to address sustainability. Aotearoa New Zealand makes amazing, delicious, nutritious foods that we share with the world. To be able to do that for the next 100 years we need to make sure we care for the environment that produces them. And we've got a massive role to play in that.

Q How is a culture of sustainability being fostered in Plant & Food Research?

A| I think the good interactions between sites is key in this. And our sites have ways to share what they're doing as part of their local updates. The fact we've called sustainability out as a key part of our strategy in two impact domains creates a focus and helps foster culture company wide. And of course, Roger Robson Willians is a structural part in all of this, and the work he does coordinating across all the site groups. But there's always the question – what more could we do? What would help us continue to improve and drive this culture of sustainability? I'm always keen to hear people's answers to this.

Q How is Plant & Food Research defining and measuring its success in improving sustainability?

A| We have a number of metrics we are working towards to define, measure and improve sustainability. We are operating alongside the targets set out in the Future Fit Business Benchmark. This has also been called out as one of our key performance indicators outlined as part of our Statement of Corporate Intent which is measured and tracked with the board quarterly.

Q Is there something in Plant & Food Research's sustainability journey that you're particularly proud of?

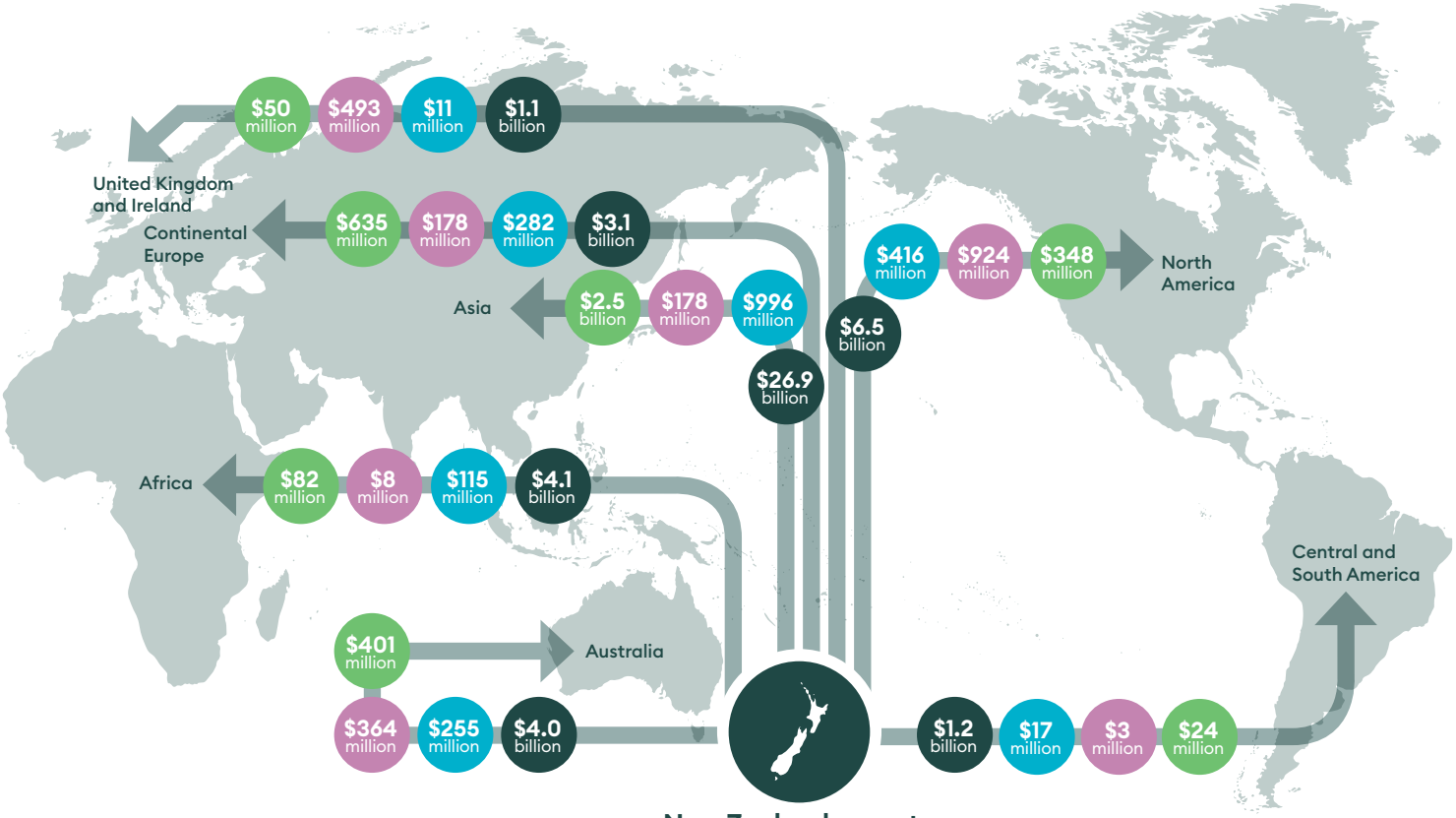
A| The biggest thing I'm proud of is the way the sites have embraced owning their own sustainability journeys. For example, when I visited Te Puke for the first time, they were keen to show me what they were doing for their own local sustainability on site. I think it's outstanding that Te Puke, as well as all the other sites, are taking charge and leading this themselves. They haven't waited for someone centrally to tell them to do it or wait for permission. And they are each doing it in a unique way that works best for the site. Moreover, I'm a massive fan of how it's actually the people that are closest to it that are leading the thinking around it.

Q What's one thing you personally do to live a more sustainable life?

A| I'm not perfect – in my job I travel a lot, and I'm a big consumer. However, I am trying to live more sustainably at home, and I am helped a lot by my wife. But one big thing I've been trying to do recently is fix things rather than buy new. I'm not that handy with my hands, but YouTube tutorials have been brilliant. For example, we had a washing machine that after 10 years was making noises. Instead of just upgrading new, I bought a new part online for $60 and with YouTube, fixed it up and got another 18 months out of it. It's a super small thing, but just changing my reference view has been great. Rather than think "I can afford to buy a new one", instead, I think "I can actually afford to fix it". And I did it with one of my kids too which was a bit of fun.

Our sectors

In 2023, New Zealand exported more than $48b of food and beverage products, more than 70% of the country's total exports. Plant & Food Research works with partners across the food sector to create new knowledge and technologies. These support development of the most sustainable food production systems in the world, delivering products that meet the demands of the most discerning global consumers.



New Zealand exports

- Horticulture
- Wine
- Seafood
- Total food & beverage $48b

Year to December 2023

Statistics source: Ministry for Primary Industries.

Scigest

Discover the world of science with the award-winning Scigest podcast.

Hosted by Plant & Food Research scientists, Scigest explores our diverse research and the incredible stories of the people behind the science, from food innovation to biosecurity and new technologies to sustainable agriculture.

Listen on our website plantandfood.com or wherever you get your podcasts.

A smart green future. Together.

Plant & Food™ Research
Rangahau Ahumāra Kai

DJS | 5/25 | CBO-3980