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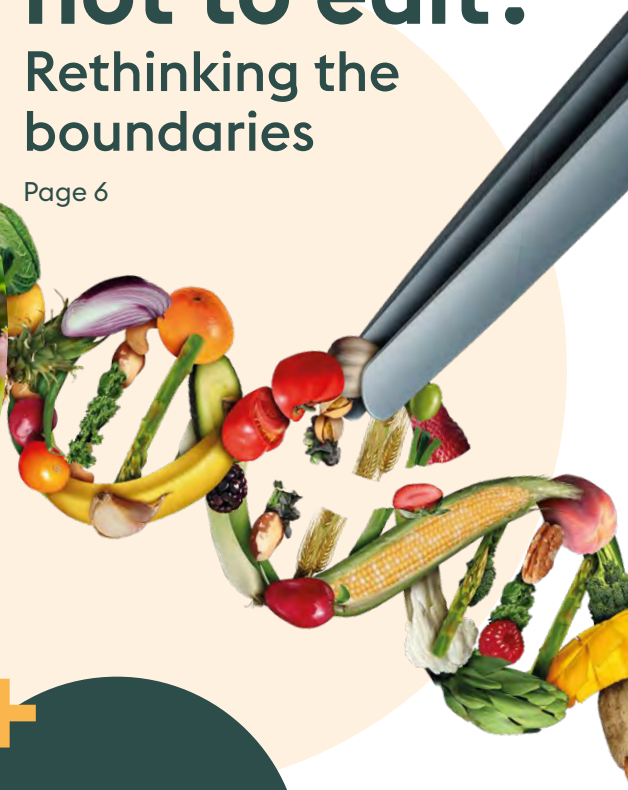

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Checking the new fruit in the orchard is part of growing the perfect avocado. Follow the avocado's journey on Page 26.

IMAGE BY BEN LAWRENCE

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OPINION

REGULARS

Welcome to Issue 4 of Segment magazine

This issue of Segment magazine focuses on the technologies that are changing the way the world produces food.

Society is constantly adapting to how technology impacts our daily lives, and food production is no different. With a growing population, increased pressure on resources, and a rapidly changing climate, there are a number of ways technology can support a sustainable, resilient food sector.

In this issue of Segment, Vincent Heeringa from The Feed looks at the six technologies that might change the way we produce food; Veronika Meduna explores how gene editing is being incorporated into breeding of new varieties, and where Aotearoa New Zealand is currently placed on the debate; and Richard Rennie looks at how we can reduce some of the challenges associated with the changing climate by growing food indoors.

We also take a photographic view of the journey from orchard to plate of one of Aotearoa's most loved fruits, the avocado, and learn more about a potential new dragon fruit sector.

As I start my tenure as CEO of Plant & Food Research, this issue of Segment magazine is an interesting insight into my fascinating new world and how science and technology are helping to provide food for our and future generations.

Mark Piper

Mark Piper
CEO Plant & Food Research

Tomatoes and potatoes could help fight cancer

A team of scientists at Adam Mickiewicz University in Poland examined bioactive compounds called glycoalkaloids and how they can play a role in preventing or treating cancer. The study found that glycoalkaloid compounds target numerous cellular pathways, which could be used to target specific mechanisms in cancer cells. The glycoalkaloid compounds could be used in conjunction with other cancer treatments to broaden the scope of their effectiveness.

Passionfruit could be vital in combatting food waste and cutting plastic use

Coloured from North Carolina State University
New research from the University of Johannesburg suggests passionfruit peel offers significant potential to preserve fresh fruits and fresh cuts in an edible coating thanks to high antioxidant and polyphenol contents, reducing food waste and decreasing our reliance on plastic packaging. By microencapsulating the antioxidants in the peels before freeze-drying and grinding the peels into a powder, the scientists produced an organic, edible coating that blocks oxygen from reaching produce while also locking in the food's naturally occurring moisture. Crucially, the coating does not interfere with the taste, colour, or general appearance of the produce.

New Zealand researchers lead world-first sequence of bilberry genome

Coloured pigments in fruits provide human health benefits. A bilberry gene-mapping project at Plant & Food Research has made some significant findings on the berry's unique pigments. The genome produced by the project is a world first and the researchers were also excited to find a genetic marker for the distinctive colour of the fruit. Although the blueberry genome has been sequenced previously, the bilberry has not, so the genome produced provides vital understanding into the differences between the two. Comparing the genomes has already helped these bilberry researchers.

A GMO purple tomato is coming to US supermarkets

The USDA has approved a genetically modified purple tomato, boasting health benefits and a greater shelf life than standard red tomatoes. Developed by a team of British scientists, the genetically modified, purple-fleshed tomato contains high antioxidant and anthocyanin contents, as found in fruits such as blueberries and blackberries. According to scientists, the new purple tomatoes contain 10 times more antioxidants than ordinary tomatoes, providing additional health benefits.

READ MORE ABOUT GENE EDITING ON PAGE 6

Coffee + milk may fight inflammation

A simple cup of coffee with milk may have anti-inflammatory effects on humans. A new study from the University of Copenhagen found the combination of proteins and antioxidants in the drink enhances the anti-inflammatory properties in immune cells. The researchers are eager to explore the potential health benefits for humans.

Scientists work on Aotearoa's own wellbeing diet

Plant & Food Research scientists are part of a team of researchers developing a uniquely Aotearoa New Zealand wellbeing diet, He Rourou Whai Painga, which they hope will tackle diabetes, heart and other noncommunicable diseases. Their goal is to develop a 'New Zealand' dietary pattern, consisting chiefly of locally produced foods that reflect our unique environment and can improve the health of our communities.

To edit or not to edit?

The past decade has seen major advancements in the field of genetic technologies, creating a new discussion on how these technologies should, could or would be used. Veronika Meduna investigates how different countries are dealing with these new techniques and where New Zealand sits in the debate.

When the Environmental Protection Authority (EPA) approved a gene-editing blood cancer immunotherapy in August 2022, medical researchers hailed it as a huge step forward in New Zealand's stance on genetic technologies. For patients with multiple myeloma, the second most common blood cancer in New Zealand, the only option had been to seek this potentially life-saving treatment overseas, at their own cost.

The therapy, known as CAR T-cell treatment, involves the harvesting and genetic editing of a patient's own immune cells to turn them into a personalised living medicine, which, once re-inserted, goes on to recognise and kill myeloma cells.

It's hard to imagine significant opposition to EPA's decision, but because of New Zealand's current regulations governing genetic technologies, this approval still counts as an uncontrolled release of a genetically modified organism (GMO).

For the Prime Minister's Chief Science Adviser, Professor Dame Juliet Gerrard, the arrival of genetically modified therapeutics is heartening and represents a "significant step forward for the ease of use of modern medicines". But it also reinforces a point she made in a 2019 briefing to the Prime Minister: our current legal and regulatory frameworks for gene editing are no longer fit for purpose.

"The scientific and legal definitions are sometimes at odds and, importantly, definitions of key concepts are inconsistent across acts. For example, at the intersection of the Medicines Act and the Hazardous Substances and New Organisms Act (HSNO), there is confusion about whether modifying human cells creates a legally defined 'new organism'."

Just as the Medicines Act is being modernised and replaced with the Therapeutics Product Bill, Gerrard would like the HSNO Act to be updated to make it "future-proof, built on a risk-based approach rather than a technology-based one, to allow the legislation and regulatory framework to cope with the rapid evolution of techniques".

Another recent development illustrates the confines of the current regulatory process even more starkly. In July, a New Zealander became the first person in the world to receive gene-editing treatment as part of a clinical trial run by US company Verve. The biotech company is pioneering an approach designed to make a single spelling change in a patient's liver DNA, to permanently turn off a gene that causes elevated amounts of LDL cholesterol, which in turn raise the risk of heart attacks and strokes, both leading causes of death.

The Gene Technology Advisory Council and MedSafe both approved that the trial could be conducted in New Zealand, but the research that led up to it would have been very difficult to carry out here, Gerrard says.

Prime Minister's Chief Science Adviser, Professor Dame Juliet Gerrard

> "The scientific and legal definitions are sometimes at odds ...

"It is frustrating for researchers when experiments in containment in the laboratory have tougher regulatory hurdles than doing the experiment in humans."

Gerrard's briefing to the Prime Minister was released to complement a comprehensive report by the Royal Society Te Apārangi that explored potential uses of gene-editing tools in health, pest control and primary production. It prompted Minister for the Environment David Parker to request advice from officials on whether any regulatory hurdles ought to be lowered "to enable medical uses that would result in no heritable traits, or laboratory tests where any risks are mitigated by containment". At the time, Parker said the government would not propose a "root and branch" review of the HSNO Act, but would look at regulatory settings for biomedical and laboratory-based research.

Dr Richard Newcomb and other scientists in Aotearoa New Zealand are calling for a robust discussion about gene technology regulations.

Since then, several other organisations, including the Commerce and the Climate Change Commissions, have called for a renewed debate about genetic editing and a re-think of the boundaries New Zealand wants to place on it. Nobody is calling for a loosening of restrictions on widespread release, but rather a fundamental shift away from focusing regulation on the technology itself to assessing the risks and benefits associated with each potential use on a case-by-case basis. "There is a fundamental question of whether to regulate tools or products," Gerrard says. "You can 3D print guns, but I haven't heard people calling for a ban on 3D printing. With a tool as powerful and far reaching as genetic editing, there is a need for a sophisticated framework."

During the two decades since the Royal Commission on Genetic Modification issued its recommendations, enshrining the principle of precaution in law, genetic technologies have changed enormously. At the time, research projects focused on transferring genetic traits – by shifting genes – between different species, using technologies that lacked precision and evoked fears of "Frankenfoods".

Because the current law and regulations are framed around technologies available back then, they don't reflect the step-change that arrived with gene editing, and CRISPR-Cas technology in particular, says Plant & Food Research Chief Scientist Dr Richard Newcomb.

"Whereas with the original genetic modification technology, we didn't know where genes were going to land in the genome, with this new technology, we target the changes to specific locations in the genome.

Perhaps the most significant difference between GMOs and modern gene editing is that the latter produces changes that could appear naturally, through mutation, or could be achieved through conventional breeding methods.

Not only that, we can make everything from a change in a single letter to adding a whole gene at that precise location. I think the gene-editing CRISPR technology deals with many of the issues people had with the original technology."

Perhaps the most significant difference between GMOs and modern gene editing is that the latter produces changes that could appear naturally, through mutation, or could be achieved through conventional breeding methods. Proponents argue gene editing is simply faster and more accurate. And given the rapid progress in whole-genome sequencing and subsequently deeper understanding of gene expression within plant and animal species of interest, there's now no need to import genetic material across species boundaries. "You don't have to add anything. You can just make a very small minor deletion or change of a single nucleotide. In that sense, you can make something that's akin to a natural mutation," Newcomb says.

For crops, the opportunities seem endless – and researchers and biotech start-ups across the world have been making good use of them. Late in 2021, a Japanese company commercialised a CRISPR-edited tomato, the first such functional food to reach the consumer market. It contains higher amounts of γ-aminobutyric acid (GABA), a naturally occurring compound that works as a neurotransmitter in the brain and is thought to lower blood pressure. The gene tech used to make the tomato was linked with digital tech to market it solely online, rather than selling more conventionally through supermarkets.

Other international projects to create gene-edited crops or livestock include corn that produces more kernels per cob, potatoes that brown less when peeled, mustard greens without the bitter taste, and slick-haired cattle that tolerate heat. In March 2022, the US Food and Drug Administration green-lit the marketing of meat from the gene-edited heat-tolerant cattle.

Dr Newcomb says New Zealand did OK during the past two decades without being able to develop GMO crops. “GM crops internationally are focused on the commodity end, whereas our food offerings tend to focus at the premium end.”

New Zealand was also lucky, he says. When we’ve had crises such as the bacterial disease Psa infecting kiwifruit, “we’ve had [resistant] varieties sitting in the wings … to replace the affected ones. I think it’s more luck than good management that we’ve been able to get through this period without the ability to use those GM tools”.

Tomatoes naturally contain a compound thought to lower blood pressure, and a new gene-edited plant has been produced with higher concentrations.

Breeding new genetically altered cows with slicker hair could improve animal tolerance to heat.

But now, he says New Zealand is increasingly out of step with its trading partners and international food regulations. The USA does not differentiate gene editing from conventional breeding. China is among a number of countries whose rules are open to gene editing of crops. Following Brexit, the UK is also moving towards lighter regulation, and even within the European Union, where strict regulations are most closely aligned with those in New Zealand, the discussion could soon be back on the agenda.

Closer to home, New Zealand's regulations are increasingly inconsistent with those of Australia, which no longer regulates genetic editing unless new DNA is included.

In 2018, the EU's highest court decided that gene editing should come under GMO regulations, giving high priority to potential risks. But the war in Ukraine is strangling imports and drought has reduced harvests across several European countries, and the European Commission has confirmed it would propose easing regulations for some specific gene-editing technologies, possibly as early as mid-2023.

Closer to home, New Zealand's regulations are increasingly inconsistent with those of Australia, which no longer regulates genetic editing unless new DNA is included. Food Standards Australia New Zealand (FSANZ) is currently undergoing its own review, proposing much lighter regulation and no labelling of gene-edited foods (as opposed to genetically modified foods). "If that goes through and is ratified, then that would put our food standards out of step with our HSNO Act," says Dr Newcomb. "We'd be able to import gene-edited foods with a much lower hurdle than making [such] foods in New Zealand."

Gene editing regulations worldwide are evolving. The Gene Editing Index ratings above represent the current status of gene editing regulations.

Wilding pines at Orakei Korako, North Island of New Zealand.

Te Puna Whakaaronui, a new think tank for the food and fibre sector, recently added its voice to calls for a renewed nationwide discussion about the "tough topic" of genetic engineering, and the potential use of CRISPR.

In a report on "reframing opportunities", chair Lain Jager lays out several ways in which gene tech could help to make the sector more resilient and sustainable: disease-resistant plants, added nutritional traits, reduced use of fertilisers and pesticides, faster breeding – and at the high-tech end of possibilities, cell cultures and precision fermentation to create cell-based meats or milks.

However, a Research First survey of consumer attitudes carried out in July 2022 suggests people continue to have deeper concerns about genetically altered foods than about the use of gene editing in therapeutics. While a third of respondents would support gene-edited fresh fruits and vegetables being for sale in New Zealand, 43% expressed concern, and almost half would worry about buying products from animals that had been fed gene-edited food. The survey also shows that awareness and knowledge of contemporary gene editing is much lower than for genetic modification.

For Dr Newcomb, the real value for New Zealand in being able to use gene editing is not to produce new functional crops, but to address climate change and environmental damage – for example, the continued spread of wilding pines. "If we could create sterile pines using this technology that didn't produce pollen or produced infertile pollen, that would be incredibly useful."

Gene editing could also generate plants that flower more quickly, which could "cut our [breeding] time from three to four years down to one year, so that we could actually breed new cultivars that would be climate resilient. With climate change marching on and the timeframes getting shorter and shorter, even around governments to meet their emissions targets, our current breeding programmes are just too slow to be able to make those changes, whether it's animal breeding to create animals that don't belch methane, or plant breeding programmes that are going to evolve plants that are resilient to the changing climate."

FEATURE

The indoor farm

Providing food security in the face of climate change

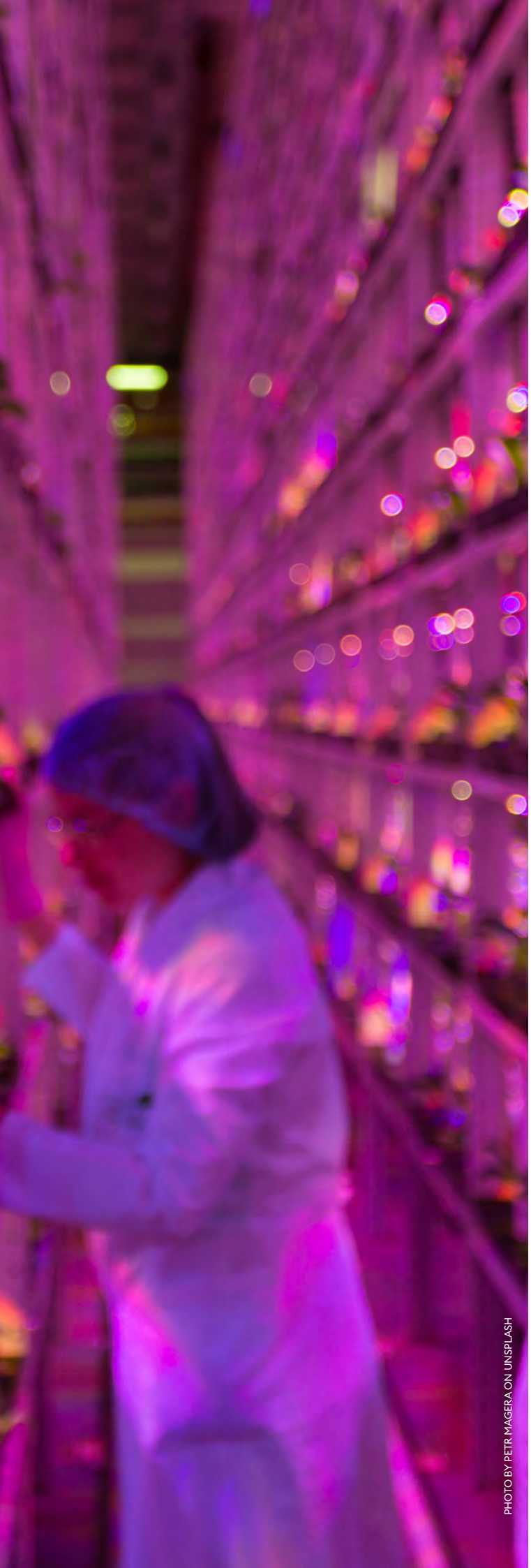

PHOTO BY PETR MAGERA ON UNSPLASH

Growing food indoors under artificial light may seem anathema to many Kiwis, given how much the wide-open, free-range nature of Aotearoa New Zealand agriculture and horticulture is taken for granted here.
But New Zealand is far from immune to the drivers that are prompting more countries to commit to indoor-based controlled environment agriculture (CEA) as a means to try and insulate from the big influencers on food availability and price.

CEA involves growing crops in an environment where key growing influences like temperature, humidity, light, nutrients, and carbon dioxide are all tightly controlled.

The growing methods are varied and include indoor growing in warehouse-type structures, where plants are stacked in layers, known as "vertical farming."

Greenhouses are more familiar to most consumers, with protected cropping under canopies also now becoming more common in Aotearoa for conventionally grown vegetables, fruits, and berries.

Drivers for change

Climate change comes top of the list of reasons to adopt CEA, as a tool that could help insulate production from its impacts.

Close to home, few Kiwi consumers would not be aware of the effects a long, volatile, wet winter has had upon vegetable prices this year.

Even vegetables supposedly in season have experienced significant shortages due to sodden conditions, and their price increase of 10% year-on-year to July 2022 was a large contributor to the country's soaring food prices.

With increasing populations has come increased pressure upon the high-value food-producing land that often encircles cities, with land being lost to housing creating even greater issues for feeding that growing population.

Since 2001 New Zealand has lost about 10,000 ha of growing land, an area just under the size of Hamilton, with Auckland alone potentially destined to lose a further 30,000 ha of high-value growing land in the coming 35 years as it approaches 2 million people.

This links to the third reason for a focus on CEA, a need for self-sufficiency.

As COVID-19 highlighted, supply chains globally are fragile, and for a country to lose its capacity to productively grow food and rely on imports makes it vulnerable to those supply chain limitations.

Combined with increasing input costs, labour shortages and shifts to more plant-based diets, intensive CEA operations are being recognised for their potential to help address those challenges. CEA is rapidly being integrated into national policies on food self-sufficiency in countries like Singapore and the United Arab Emirates.

New Zealand works to keep up on CEA advances

Science Group Leader at Plant & Food Research, Dr Samantha Baldwin, is leading the research direction at the organisation focused on urban horticulture and controlled growing. Her work includes understanding the complex dynamic developing between more intensified urban populations and how best to ensure they have a reliable, affordable food supply.

She sees a move to more intensive CEA farming as one that has already begun, albeit in a small way here in Aotearoa, as more outdoor growers try to mitigate climatic risk by using canopies, netting, and tunnelling on their high-value vegetables, fruit, and berries.

This has been driven as much by the increased occurrence of devastating climatic events like hail, unseasonal frosts, and wind damage, as by greater difficulties in acquiring crop insurance.

Baldwin points to the efforts in the rest of the world in intensify CEA farming, and the catalyst it provides for her and her colleagues here to keep up, or risk being left behind.

“Countries like Singapore and the United Arab Emirates have triggered a great deal of investment in this area where they want to be growing more produce locally. Going under cover and upwards is the only option.”

Singapore, for example, has adopted a “30 by 30” food policy. The city state is aiming to produce 30% of its nutritional needs by 2030, a significant increase from its current 10% in a country where only one percent of the land is available for food production.

Its US$45 million AgriFood Cluster Transformation fund is specifically targeting a higher rate of adoption of CEA technology, ultimately creating a hub of countries with export-leading technology.

In 2022 Dubai opened ECO1, the world’s largest vertical farm, which aims to produce over 900 tonnes of leafy greens annually. The initiative is a collaboration between national airline Emirates and a private company. It is based in a 30,000sqm farm producing spinach, rocket, herbs and lettuces, and will target airline passengers as one of its main markets.

Singapore has adopted a “30 by 30” food policy. The city state is aiming to produce 30% of its nutritional needs by 2030, a significant increase from its current 10% in a country where only one percent of the land is available for food production.

PHOTO BY SWAPNIL BAPAT ON UNSPLASH

In Europe the continent's largest farm is being built outside Copenhagen by start-up company Nordic Harvest in a 7000sqm facility growing plants stacked 14 layers high. The operators claim the facility will use 250 times less water and occupy 250 times less space than the equivalent outdoor grown crop.

Scotland-based firm Intelligent Growth Solutions (IGS) is developing vertical farming systems that may ultimately be found in New Zealand.

The company made its first appearance at the New Zealand Fieldays in 2021, winning the Fieldays Innovation Award in the growth and scale category, and is now discussing opportunities here.

CEO David Farquhar says on its own vertical farming will not solve the world's hunger or climate change challenges, but could ultimately provide up to 30% of the world's diet for vegetables and fruits.

Making the plant the star

Baldwin says facilities tend to favour leafy greens because of their short cropping rotation, usually only a few weeks from initial germination to harvest, while growing costs are relatively low and there is a well-established playbook for growing successfully.

Playing to Aotearoa's strength in horticulture and good crop husbandry, Samantha's team are looking ahead over the coming decades at how the country could use the methods to grow woodier, more vegetative perennial-type plants, such as blueberries, grapes, and fruit trees like cherries.

Locating CEA crops closer to their ultimate consumers not only reduces supply chain length and fragility, it also offers the opportunity to capitalise on the waste streams those dense population centres generate.

"These can include city-generated waste heat and CO_2 that can be pumped into facilities to help with growth rates, helping create a circular system," says Baldwin.

Their current workstream is focusing on how to completely re-think the 'ideal' plant for CEA, getting a deeper understanding of crops' genetic makeup, physiology, and physical appearance.

"Being able to isolate and control all those factors like light, temperature, humidity, and nutrients, which is so difficult to do outdoors, means we can really measure how the plant responds to each parameter. And how do we modify those environmental parameters for an optimal response?

"We really make the plant the star of the research."

The researchers are working on being 'crop agnostic', examining the responses of a number of species including kiwifruit, apples, and berries.

Some New Zealand companies are already making inroads within the CEA industry and moving beyond the conventional leafy greens crops.

TOP: Dr Samantha Baldwin is leading a team looking at developing new fruit trees that can grow indoors.

BOTTOM: Dubai's ECO1 vertical farm aims to produce more than 900 tonnes of leafy greens annually, with a key focus on airline passengers.

Strawberries under a roof

Wellington-based CEA company 26Seasons is one of Aotearoa's largest companies of its type.

CEO Grant Leach said the company is well advanced in developing an indoor strawberry business, in addition to its established mixed microgreens operation.

That microgreen operation is claimed to be many times more productive per square metre than its outdoor equivalent, harvesting the hydroponically grown crops every two weeks, hence the company's name. Its strawberry operation is claimed to be about eight times more productive per square metre than outdoor equivalents, owing to the vertical nature of growing.

Based in its Foxton premises, several years of trialling has resulted in identifying a hybrid strawberry variety suited to indoor growing.

However, Leach puts the challenge of growing a crop like strawberries at the top end of the difficulty scale compared with micro and leafy greens.

"To get a commercially viable business you have to be able to also deliver consistently good quality fruit at a high yield, ensuring you have the ability to manage the shifting nutritional profile that comes with each growth stage, with pin-point accuracy."

Pollination, climate and pest management inevitably add to the challenges.

"Then you need the technology to monitor, diagnose problems and respond in a very timely manner. That is critical in any system we use."

The company has 600m^2 of space committed to a proof of concept and aims to double that in the coming year.

"We foresee the ability to supply strawberries out of season. We are not focused on competing with local growers in season. We see an opportunity to grow for the entire market and remove the need to rely upon carbon intensive overseas berries to meet that demand."

Ultimately 26Seasons would like to develop a hub of CEA expertise in the Horowhenua district.

Growing Kiwi technology

In Waikato at Ruakura Innovation Park, start-up company Greengrower is leveraging the city's talent pool that covers both agronomy knowledge and mechanical engineering talent in commissioning its first indoor operation.

CEO Tom Schuyt said he sees a confluence on technology, resource challenges and consumer demand all driving CEA's growth.

New Zealand company 26Seasons, cofounded by Matthew Keltie, is incorporating strawberries alongside its microgreens operations.

Scientists at Plant & Food Research, like Bouche Jacques-Joseph, are looking at what plants need to grow in controlled environments.

Technology improvements in LED lighting and sensor tech that can help better monitor plant performance have also had a role to play in a system he said used only 1% of the water that conventional systems use and recycled 99% of that water.

Developments in solar technology mean the company is also looking at future partnerships with solar generators to provide a zero-carbon electricity source, as they ultimately work towards zero-carbon certification.

The company is working with the US vertical farming company Elevate to 'kiwi-ise' their systems at the Ruakura site, which he said would generate the equivalent in leafy greens that 150 ha of bare land would do.

Tauranga-based company Bluelab can claim some of the industry's leading technology for CEA crop monitoring and diagnosis.

A major player in CEA monitoring and diagnostics, CEO Jono Jones takes a global view of the sector's growth. He says the United States is an interesting market, now with over 2000 vertical farms.

With up to 90% of its vegetables and fruit coming out of California, the country has very long supply chains which are helping reduce energy costs and transport times.

Here in Aotearoa, Jones believes the volatility of climate change will be a key driver for considering CEA, while future climate change impacts like greater humidity in northern New Zealand could also prompt a need to grow more crops indoors, as is required in Southeast Asia.

"One of the biggest challenges for vertical farming is energy. A vertical farm will generally expand more CO_2 per kg of produce, but the water consumption will be significantly lower. But the emissions can be managed, which comes back to energy."

Jones believes New Zealand's high level of renewable energy could do much to contribute to CEA having a lower carbon footprint.

Taking CEA systems to the world

Baldwin says the next big step for 'New Zealand Inc' is what technology developed here could mean for entire farm systems, both here and abroad.

"It could become a great deal more like remote growing, where we sell the technology under a licence agreement.

"Locally it could mean every housing development could have its own 'farm'. With two thirds of the world's population living in cities by 2050, de-centralising supply chains and boosting accessibility will only become more critical.

"If we could design growing systems capable of producing the food we need, without stepping beyond our city block, that will have many benefits environmentally and socially," she says.

Reframing farming

DR ROGER ROBSON-WILLIAMS,
CHIEF SUSTAINABILITY OFFICER, PLANT & FOOD RESEARCH

I'm starting a thought experiment for 2023: How differently might I view sustainability in the primary sector if I stopped thinking about the commercial-scale growing and harvesting of kai as an industry?

This is not an original idea. In 1973, Ernst Schumacher wrote in Small is Beautiful (my summer reading), "The question arises of whether agriculture is, in fact, an industry, or whether it might be something essentially different". Written fifty years ago and from a European perspective, it got me wondering whether, in 21st Century Aotearoa New Zealand, 'industry' is really still a useful, or relevant, way to frame the production of food and drink from our land and oceans?

The word 'industry' is really a specific macro-economic description for a branch of the economy. So when we use 'industry' as the collective term for our horticultural, arable, pastoral and seafood sectors, it implies to me a primarily economic imperative. That's not all wrong – the individuals, families and organisations that work in these parts of our primary 'industries' unquestionably make a huge contribution to the economy. But they can also feed us, nourish us, nurture our land and protect and preserve nature that we value. The outcomes of farming, growing and fishing influence our diets, our wellness, our landscape and our culture.

It feels to me that by framing farming as an industry we unconsciously privilege economic outcomes over these more holistic impacts.

You may wonder if any of this matters. I believe it does because we're now asking more from our food producers than ever before – and the resources they draw on to meet our needs are finite and fragile. It is hard work to farm and even harder work to do so while changing your system to meet the realities of our challenged ecosystems. I like to recognise producers who are working to achieve this. I sing their praises and where possible I buy their products – perhaps a little too much from a local vineyard, but they are doing such a good job ...

Here in Aotearoa, it is not difficult to find food and farmers worth celebrating. However, it is also true that much primary and secondary industrial activity worldwide is associated with the unsustainable extraction of finite resources. Nature's bounty is then processed into goods which ultimately end up being discarded and causing pollution. A group of young researchers in the USA set out this bleak assessment with great clarity in their 1972 book, The Limits to Growth (my summer reading last year), and made themselves quite unpopular in some circles in the process.

Rather little has changed in the intervening years except a realisation that, in contrast to many industrial activities, the growing and harvesting of kai can be achieved in ways that do no harm and are even regenerative to both environment and society. This is something that many indigenous peoples around the world have been pointing out for years. Now governments and consumers increasingly recognise this and are becoming more explicit about the multiple outcomes required of those who manage our lands and seas.

The potential scale of non-financial outcomes is very significant. For example, the Intergovernmental Panel on Climate Change has identified improved management of farmlands as one of the five most effective strategies for reducing greenhouse gas emissions. What we farm and how we do it are major tools to address one of the principal threats to humanity.

If we agree that the way we grow and harvest food can deliver much more than simply good nutrition, useful economic activity and much needed climate change mitigation, it begs the question: "What else is possible?" My short answer is "Plenty". Here's a slightly longer version ...

In December 2022 Aotearoa New Zealand adopted the Kunming-Montreal Global Biodiversity Framework – an international initiative to protect the planet's lands and oceans from further degradation and to restore ecosystems already degraded. This provides impetus to acknowledge, embrace, monitor and improve the regenerative capacity of our food production systems.

We're going to need to work with the economists on this one – even if we don't all use the same language

> **... framing food production as an industry unhelpfully implies an emphasis on the economic dimension and overlooks the uniquely regenerative potential of food production**

to describe our goals and mahi. Measuring outcomes in financial terms across many aspects of human endeavour is commonplace and can provide useful insights. To measure the degenerative and regenerative impacts of a particular farming system is difficult and relatively new, but now imperative.

An international Taskforce on Nature-Related Financial Disclosure, established in June 2021, is one response to this need. Its purpose is to provide a framework for organisations to report and act on nature-related risks such as habitat degradation or biodiversity loss. Science-based organisations such as Plant & Food Research have a role here in helping to define the important metrics and provide credible means for their measurement and reporting. In Aotearoa New Zealand we also have the advantage of Mātauranga Māori and an acknowledgement of the connectedness of people and planet. (It is worth noting that the Te Reo word for industry, ahumahi, is built from the verb ahu which means to tend, foster or nurture.)

And what have I learned so far from my own rethinking of 'industry'? It's leading me to conclude that framing food production as an industry unhelpfully implies an emphasis on the economic dimension and overlooks the uniquely regenerative potential of food production. And there is plenty more to ponder. Reflecting on the benefits and pitfalls which have come from applying 'industrial' methods and mindset to agriculture to date, I am left wondering whether these will be different as we increasingly rethink 'farming' though a technology lens.

Innovations in fermentation technology and cell culture are beginning to provide economically viable analogues of milk, meat and other foods. Vertical or urban farms growing plant materials, currently mostly leafy greens, under highly controlled and virtually hermetically sealed conditions, are also a reality in some cities. These means of food production are self-evidently "essentially different" from outdoor farming and perhaps justify the label 'industrial'. Whether they are part of the primary sector or not is moot.

I will continue my thought experiment motivated by Ernst Schumacher's provocation that growing and harvesting kai "might be something essentially different" from an industrial pursuit. I hope it will help me to see new opportunities to engage consumers, reconnect people with the land and water, and attract the next generation of people considering a career in horticultural, arable, pastoral or seafood production.

And if it helps me spot one or two new farms and wineries to 'celebrate' with my custom along the way, then that's very welcome too!

Six technologies changing how food is produced

Feeding the world is turning out to be quite difficult. As fast as the global population is growing — with 9 billion mouths to feed by 2050 — hurdles to food production keep mounting.

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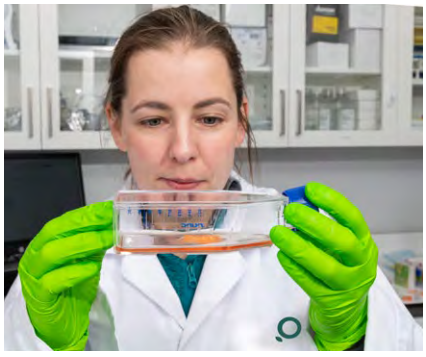
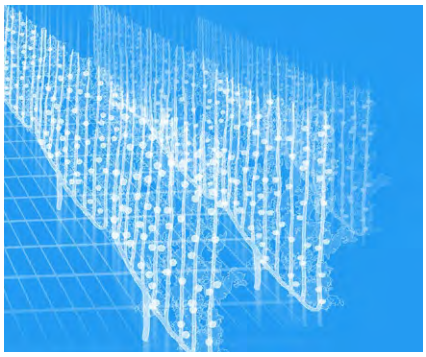






Natural resources essential for growing – healthy soil, fresh water and clean air – are under pressure on all sides, from nutrient run-off to urban sprawl. Climate change is sending unseasonal droughts and storms, and sparking wildfires. Localised wars and unrest are affecting supply chains globally.

The productivity improvements that marked the 'green revolution' of the late 20th century are tailing off, requiring ever-growing use of agricultural inputs like fertilisers, agrichemicals and irrigation.

And counter-intuitively, we're producing too much food in some parts and insufficient in others. The supply chain is misaligned, producing astonishing volumes of food waste.

At Plant & Food Research we're tackling these challenges head on. The Productivity Commission recently advocated for changes to agriculture and for much more technology adoption if New Zealand is to reduce emissions and lift food productivity. We agree – and are investing in the science to get there.

Here are six technology advancements that Plant & Food Research believe could help solve multiple food problems – and grow our primary industries at the same time.

1. Open ocean aquaculture

New Zealand has one of the largest exclusive economic zones, if you include our oceans – our 'blue economy'. So far we've harnessed it by fishing our wild stocks.

An alternative is fish farming. Half the world's seafood comes from aquaculture but, despite our large ocean real estate, our coastline has relatively little area suitable for aquaculture. Our current aquaculture can be affected by coastal change such as rising sea temperatures, as was recently reported in the Marlborough Sounds.

If we could grow fish in the open ocean, where the currents flow fast and the temperatures remain more even, we could dramatically increase the supply of fish and reduce coastal impact. Open ocean aquaculture is used overseas in so-called static systems, with fixed pens tethered to the ocean floor or engineered structures.

New Zealand scientists are taking a novel approach. A consortium of science organisations, including Plant & Food Research, are pioneering mobile fish farms – pens that can move to find the most ideal waters in terms of temperature and oxygen, and operate far from land. The pens offer multiple benefits: reduced coastal impact, fewer vulnerabilities to climate and, excitingly, the production potential for taonga species like snapper and trevally.

Dr Damian Moran, Leader of our Growing Futures™ Ngā Tai Hōhonu Open Ocean Aquaculture Direction, says aquaculture has the potential to be an efficient, low impact protein, production system.

"One of the best ways we can help to alleviate pressure on the land is to move some of our production to the sea. It's about changing how we make and consume protein.

"The ocean is really an unexplored opportunity."

2. Lab-based meat

Fancy a juicy snapper fillet? How about one grown in a lab? The 'cultured meat' revolution involves growing animal protein in factory-style conditions. The technology has been bubbling away in labs for a decade now and is nearing commercial release. Cultured chicken nuggets are already being sold in Singapore.

Cultured meat will be produced in large volumes in small factories, not farms, with minimal water and sunshine requirements. And of course, no slaughter. It may even convert a few vegans.

New Zealand is no slouch in this field. Dr Georgina Dowd is leading a project to produce cultured snapper and salmon. The task involves establishing continuous cell lines for Aotearoa's finfish. In addition to the potential for growing protein for food, the cell lines would help support the future of our seafood industry.

"There are so many applications for cell lines," says Dowd. "Preventing and monitoring disease is probably the biggest. It's only a matter of time before one of the detrimental diseases arrives here and affects our seafood industry. Unless we put systems and pipelines in place, we are really at risk."

Dowd has established New Zealand's first dedicated fish cell lab and is building an expert team and international network of collaborators in Canada, the USA and Singapore.

3. The new breeding

Traditional breeding of perennial crops is slow. Even with modern advances in genomics to screen for important characteristics, it can still take 15 years to get a new cultivar to market.

New breeding technologies, like gene editing with CRISPR, have the potential to help us adapt and change our food at a fast rate. “Using these sophisticated editing tools we can cross plants ten times faster than with traditional breeding,” says Professor Andrew Allan, who leads a major project into the effect of climate change on flowering plants.

“I just don’t think our traditional breeding techniques will be fast enough for climate change,” he says.

In the 1950s and 1960s an agricultural revolution involving the breeding of dwarf phenotypes into rice and wheat saved populations from starvation. Allan says we need a similar revolution now to face the climate crisis and protect food security for a rapidly expanding global population. Many plants may fail to flower and fruit as night temperatures warm, for example, since they require colder temperatures to trigger flowering. Gene editing could help meet this challenge without using chemicals.

“Could gene editing be something for New Zealand to consider?” he asks. “There are small gene edits that could bring huge benefits to Aotearoa, and similar to the changes that occur, just more slowly, in nature or conventional breeding. If we want to mitigate or even reverse the impacts of climate change, then we are going to need to use as much innovation as possible, quickly.”

4. The farm next door

Imagine popping out from your office job to pick berries for lunch, or a fresh cucumber or an apple – all from the same system. That dream for vertical farming is growing ever closer, thanks to the work of scientists such as Dr Samantha Baldwin, leader of our Hua ki te Ao Horticultural Production goes Urban Growing Futures™ Direction.

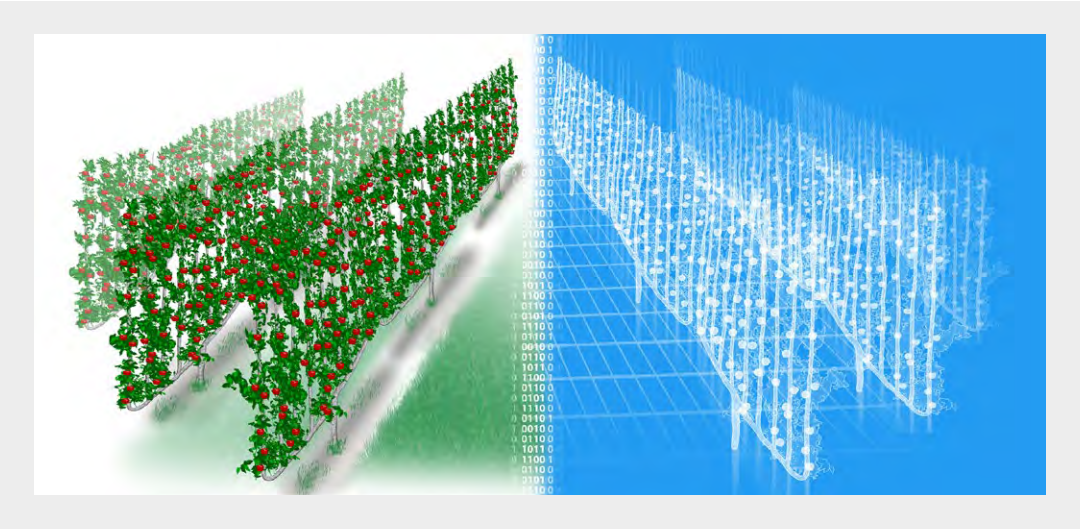
Vertical farms are already popular for growing leafy greens and micro-greens. Vertical farms grow crops in artificial settings, with LED lights and hydroponic systems and can be as large as a factory or as small as a cupboard.

Baldwin is working on the next generation of vertical farms. “Imagine a single structure that produces a range of fruits throughout the year – maybe you could have berries, peaches and cucumbers from a single source whatever the season.

“We could have vertical farms in the centre of the city, or each have a growing box in our home, where we could ‘dial up’ whatever fresh fruits or vegetables we needed – the box would be programmed to control the light, humidity and other conditions to make the produce perfect at the time we wanted to eat it. We’d even be able to grow fruits and vegetables far from their usual growing zones or out of season.”

That may sound like science fiction, but new forms of growing systems, programmed to provide the right environment for plants to grow and produce to order, are within reach. They would require new forms of plants that could produce fruits and vegetables year round.

PHOTO BY PETR MAGERA ON UNSPLASH



Creating a digital twin, that mirrors a living orchard, can help predict how fruit production will be affected under different climate scenarios

Some of those challenges could be met with new technologies like gene editing – breeding plants with the characteristics needed to thrive in new growing systems and that will produce food year-round, close to an increasingly urban population.

5. Zero waste factories

Imagine putting a fish in one end of an energy efficient processing plant and getting high-value products at the other – food, industrial materials or cosmetics, with nothing left over. To make this dream a reality, our scientists and engineers are developing new adaptive manufacturing technologies that can respond to any marine raw material and allow optimal processing choices.

"We need to think of a fish as being more than food, valuing the whole organism and what it contains. Of course there are fillets, shellfish, stocks and flavourings but marine organisms also contain a wealth of compounds including bioactives for body, skin and hair and large polymers for biomaterials. This creates huge potential to add value to our fisheries without catching more fish" says Dr Sue Marshall.

Marshall is part of a world-leading team bringing together New Zealand and international experts in industrial chemistry, biomaterials and technology development, as part of the MBIE-funded Cyber-Marine programme.

"New Zealand is already producing some marine nutraceuticals and biomaterials, but there's so much opportunity to do more. We're working towards using everything, optimising value, reducing energy and water use, and making exciting new products that will give us an edge in our export markets" says Marshall.

6. Digital orchards

Digital twins are used in a variety of sectors – from manufacturing to medicine – but no one yet has created a digital orchard. Enter Dr John Mawson, leader of the Growing Futures™ Digital Horticultural Systems Direction.

A digital twin could help scientists and growers predict what would happen as a result of multiple future scenarios: increasing carbon dioxide, rising temperatures, change of crops, altering pesticides, introducing natural predators and so on.

It could also improve the alignment of growing food with consumer demand. The digital orchard project includes market data and all the points in the supply chain. With this level of information could we predict consumer demand and adjust the supply chain before the shopper even asks for it?

"Creating digital models for crop growing isn't new, but these usually address a particular crop and a particular aspect of the production system, such as helping growers make decisions on water or fertiliser application. What we're aiming for is a digital twin that could take data across all potential scenarios in the supply chain – from what crop to plant and how to grow it through to how to process it or where to ship it – then we could tweak one aspect and track the knock-on effects right through to the consumer," says Mawson.

Conclusion

The rising global population and the environmental and geopolitical stress that this brings is putting huge pressure on our food systems. Science and technology are not the only answer but can certainly contribute to accessible, nutritious and delicious solutions. At Plant & Food Research we are committed to playing our part.

GLOBAL FOOD LEADERS

An interview with Arama Kukutai, Plenty

Segment chatted to Arama Kukutai (Ngāti Tipa, Maniapoto, Te Aupōuri) about the future of agritech in Aotearoa and beyond. Kukutai has been an agribusiness entrepreneur for two decades and is a thought leader in agrifood sustainability and investment trends. He is CEO of Plenty and Co-founder of pioneering agritech venture fund Finistere Ventures. He was previously Executive Chairman of PKW Farms and led New Zealand Trade & Enterprise (NZTE) in North America.

How did growing up in the Waikato region shape your view of the world and influence your career development?
My whakapapa is to the Waikato, Taranaki and the Far North, but our home marae is the Tūrangawaewae, in the Waikato. My grandmother used to run the pā garden, and I have memories of digging up the lupins, which were used as an organic fertiliser. Our whanau has close links in farming, and worked to build a resilient food supply while being guardians of the land. This has always stuck with me and is what inspired me to expand my focus beyond a single farm to technology that can benefit lots of farms. The work we do at Finistere Ventures, for example, looks at how we can use technology to feed the world sustainably.

As a Co-founder of Finistere Ventures, you've seen many innovations in agritech. How do you think technology could shape the future of the horticulture industry in Aotearoa New Zealand?
Horticulture is a really specialised area of agriculture. In Aotearoa, it tends to be focused on a specific crop for a specific piece of land, whether that's kiwifruit in the Bay of Plenty or wine grapes in Marlborough. However, the amount of land we can farm is finite, so if we want to get more from that resource we have to think differently. For example, at Plenty, we can get 300 hectares worth of produce from one hectare of land by growing vertically and indoors. We can also get harvests year-round. Aotearoa has a good environment for more energy-efficient indoor growing – you won't have to use a lot of energy keeping the temperature static as you do in climates with extreme heat or cold – and removing reliance on the sun and the weather could dramatically speed up both food production and the breeding of new plant varieties. Aotearoa's biggest challenge is staying connected to the outside world and accessing the best of others' technologies. There's a limit to how much innovation is possible with a small population and an opportunity to accelerate the evolution of New Zealand's food production by leveraging technology and partners from around the world.

What are some of the agritech innovations you're most excited about right now?
I think moving some of our food production indoors is going to be huge – what I call the "hybrid agriconomy". At the moment, less than 1% of food is grown indoors. By investing in and growing those capabilities, we will see a real shift in food production over the next 30 years. In addition to indoor or vertical growing, I think we'll see our sources of food expand through more cultivated, or lab-grown, meat and precision fermentation. For outside production, there will be a continuing digitisation of agriculture, so farmers can get a better understanding of what's happening on their farm. Not having time to enjoy life is one of the biggest reasons I hear for people getting out of farming, so getting more time back through use of technology is a compelling incentive.

As CEO of Plenty, indoor growing is obviously top-of-mind a great deal of the time. What are some of the hurdles for the growth of this technology?
Any innovation is capital intensive, and getting new technology off the ground can be really hard. Indoor agriculture is a new asset class that a lot of mainstream investors, like banks, haven't come across before so they don't have the confidence to hand out large capital investment. With Plenty, we're answering questions about how we can make indoor growing economical, and demonstrating the sustainability credentials of our farms and our technology. Hopefully that will make it easier for others to gain the investment needed to scale.

You've talked before about the need for new Plenty operations to integrate with the local community. Why is this important to you?
Food is integral to people's lives. We really take pride in doing something that can have a positive impact on both people and the planet. Building a farm is a long-term commitment to a place, so being part of the community is important. Our first farm is in Compton, a small city in Los Angeles, which is well known in large part because of the talented people who come from there, such as Serena and Venus Williams, Kendrick Lamar and Dr Dre. The opportunity to hire locally and be a supportive and engaged part of the community was a big part of what made Compton such an attractive location for our first commercial farm. Our next farm is going to be in Virginia, on the other side of the USA, which is a very different place with its own opportunities and challenges. The plan is for each of our farms to earn the right to be relevant to the community it's based in, having its own identity within the values we have as a company.

You are launching an internship for Māori STEM and business graduates to engage with a global network. How is that progressing?
The internships are an exciting project, and a way for me to build on the great opportunities I've had. Te Ara Pōtiki, which we're in the process of launching, will help Māori rangitahi (young people) explore and build connections outside of home. The Māori economy is estimated at $70 billion, but arguably our biggest resource is our people. Through this internship we'll provide young scientists and commercial leaders with opportunities in technology companies to help them build their careers and their networks. We're expecting the first cohort of interns in the USA during the New Zealand summer, essentially the "off season" for interns in the northern hemisphere, and we're offering three experience tracks – engineering/software, science disciplines and entrepreneurial – which are all vital in building food production for the future.

How does food feature in your home life?
With a young family, it's really interesting to watch what my kids eat as they grow. In my day, you ate what you were given, but kids these days have so much more choice. My daughter, who's 12, is eating less meat, and really embracing meat alternatives. I think we're all getting more used to focusing on the fresh produce outside of the grocery store, as the packaged goods, like cans and paper towels, found in the middle are easy to buy online. Like most families, we're busy, so we're looking for food that's convenient. The key is balancing what's good for us with less fuss, which is what's great about Plenty produce. It's pesticide-free, so you don't have to wash it – you can literally just open the pack and eat.

From tree to plate — an avocado's journey

PHOTOGRAPHY **BEN LAWRENCE**

An avocado flower. 'Hass' avocado flowers alternate between being male (producing pollen) and being female (receptive to pollen) at different times on different days. Under ideal conditions, there will be both male and female flowers open at the same time to ensure cross-over of pollen. A mature avocado tree can produce about one million flowers each year.

Young avocados begin to develop on the tree. Only about 0.3% of flowers develop into fruit in the orchard, although hand pollination can increase fruit set to around 5%. Plant & Food Research scientists are investigating ways to improve pollination so growers can be confident that pollination is not a limiting factor for their crop.

“The avocado is a food without rivalry among the fruits, the veritable fruit of paradise,” exclaimed David Fairchild, the man who introduced avocados to the USA in the early 20th Century.

A so-called ‘food explorer’, botanist Fairchild traversed the globe for the US Department of Agriculture, seeking out new plants that could be introduced to American growers and consumers. Just a few years later, in the early 1920s, the first commercial avocado orchard was established in Aotearoa New Zealand from seeds produced in California.

Avocados originated in central America, where most avocados are still grown today. By contrast, Aotearoa New Zealand produces just 2% of the global supply of avocados. However, the consistent high quality of avocados produced on our 4,000 hectares of avocado trees creates high demand in export markets, particularly in Asia.

Whether served on toast, in a burger, as guacamole, or topping sushi, the avocado is a staple of the Kiwi diet.

A hover fly visits an avocado flower. While honey bees are used as managed pollinators in avocado orchards, native insects such as hover flies provide important additional pollination services.

Maturing avocados hang from the tree. Avocados are ready for harvest between September and April in Aotearoa New Zealand, and begin to ripen when removed from the tree. Avocados harvested later in the season have more developed taste and consumer appeal, but also run greater risk of damage from late summer storms.

Scientists Nick Gould (left) and Andrew Barnett inspect avocado trees in the experimental orchard. Avocados trees tend to produce large crops one year and smaller crops the next year. Scientists are investigating ways to reduce this irregular bearing, to maintain more predictable crop volumes year-on-year.

Scientist Phil Elmer samples an orchard for the presence of fruit rots. Postharvest fruit rots, the black/brown areas which develop when the fruit are ripe and ready to eat, are the biggest issue affecting avocado quality and consumer appeal. The MPI-funded AvoVantage project, aimed at improving avocado quality, has identified orchard factors that can reduce postharvest rots after avocados are harvested and cool-stored.

Avocado trees can grow up to 10 metres tall and the fruit are harvested by hand-picking – in commercial orchards, hydraulic harvesting machines enable the harvester to pick quickly.

A tractor gathers bins of harvested avocados. The average avocado harvest is about 11 tonnes of fruit per hectare, with some orchards harvesting up to 59 tonnes per hectare.

Avocados are sorted in a packhouse. Once harvested, avocados are sorted by size and to remove any with visible damage. Avocados are then packed into trays for export, primarily by sea freight in refrigerated containers.

A fresh avocado is prepared for eating. Consumers in more than 25 countries around the world enjoy eating New Zealand avocados.

The mighty dragon fruit

The popularity of dragon fruit is on the rise with brands like Starbucks, Krispy Kreme and Snapple offering dragon fruit products. Native to Central and South America, many regions now grow dragon fruit, including Asia and the Middle East.

Dragon fruit contain antioxidants and prebiotic fibre as well as vitamins and minerals and are prized in many parts of Asia where its red colour is associated with good fortune.

The juice of the dragon fruit provides a natural colourant and the fruit can be processed into products like energy bars and ice cream, while by-products from processing, such as the skin, offer applications in the food and pharmaceutical industries and could add value for the industry.

A new crop for Aotearoa?

Could dragon fruit become a new commercial crop for Aotearoa? A pilot trial at Plant & Food Research's Kerikeri site was established in 2020 to determine the climatic adaptation and economic feasibility of growing dragon fruit in New Zealand. Scientists have been testing cultivars developed in Viet Nam with those available locally to assess the crop's potential.

While Aotearoa's cold and wet winter weather is not ideal for dragon fruit plants, the crops can thrive in raised mounds or in large pots. Combined with the use of covers/tunnels, these measures could enable dragon fruit to grow in a range of conditions and soil types, including unproductive land.

Dragon fruit grow on a type of climbing cactus that produces fruit for 20–30 years.

Super-charging the dragon fruit industry in Viet Nam

Plant & Food Research has been working with the Southern Horticultural Research Institute in Viet Nam since 2013 (as part of the New Premium Fruit Variety Development Project (NPFVD)) to increase the value of the dragon fruit industry. Despite being the world's largest dragon fruit supplier, there is an opportunity for growth in Viet Nam's dragon fruit industry. Taking the best from Aotearoa's success stories like 'Scilate'/Envy™ and Zespri™SunGold™ Kiwifruit, there is an opportunity for proprietary dragon fruit cultivars to underpin a controlled production commercialisation model with all parties in the supply chain benefitting from growth.

Plant & Food Research scientists have developed three new cultivars that offer novel flavours and colours for global consumers as well as tolerance to canker disease, which has devastated dragon fruit plantations in several countries. VentureFruit™ have exclusive global commercialisation rights to these new varieties.

Alongside the new cultivars, the scientists also developed a new growing system with the potential to cost-effectively double yield. This T-bar system replaces the traditional mop-top growing system and, in addition to lifting yield, allows excellent spray coverage for pest and disease control.

Drawing on understanding from other crops, Plant & Food Research have worked with local partners in Viet Nam to improve post harvest practices, ensuring the fruit arrive with consumers in optimum condition and satisfy the demands of export markets.

Dragon fruit flowers bloom only at night.

Yoghurt

Yoghurt and other products containing active cultures are excellent sources of probiotics. Often associated with digestive health, some probiotics have been shown to play a role in reducing stress and anxiety. Yoghurt can also provide you with potassium and magnesium, which helps oxygen reach the brain, further improving its ability to function.

Berries

Berries are rich in phytochemicals called anthocyanins, powerful antioxidants which help protect cells from damage by harmful free radicals. Found in deeply pigmented red, blue, and purple foods anthocyanins are great for the brain as they help reduce inflammation that is linked to depression. Anthocyanins have also been shown to improve memory, strengthen the heart and reduce the risk of certain cancers.

What you eat affects not only your physical health but also your mental health. You can improve your mental well-being by making changes to your diet. Fortunately, the eating habits that keep you mentally well are those that support your physical health too. Here are six nutritious foods that can help boost your mental health:

Mood Food

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**

Avocados

Avocados are rich in several stress-relieving B vitamins as well as the antioxidant vitamin E and heart-healthy fat that may help to lessen anxiety The brain needs B vitamins for healthy cell structu and the production of neurotransmitters, like serotonin, which influences our mood. A deficienc of B vitamins has been linked to increased anxiet in some people. Monounsaturated fats found in avocados have anti-inflammatory properties tha may lower the risk of depression.

FOR MORE ABOUT AVOCADOS SEE PAGE 26

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Whole Grains & Legumes

Rich in B vitamins, whole grains are important for energy and optimal brain health. Whole grains and legumes, such as beans and lentils, are both excellent sources of quality carbohydrates, meaning they're slowly digested and provide sustained brain fuel, helping you feel energised throughout the day. Whole grains and legumes are also naturally high in tryptophan, an essential amino acid that is important for the production of serotonin in the body, commonly known as the feel-good mood-stabilising hormone. Legumes are also an excellent source of magnesium and zinc, both of which have been linked with improved brain health.

Nuts

Some nuts, like walnuts, are a source of omega-3 fatty acids and may help reduce the risk of depression. Cashews are a good source of magnesium which plays a role in neurological health. Almonds contain a compound called phenylalanine, which is shown to help the brain produce dopamine and other neurotransmitters that support your mood. Another benefit to nuts is that they are a great source of unsaturated fat, and research suggests that people who eat more unsaturated fat (and less saturated fat) are less likely to have anxiety.

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6

Salmon & other oily fish

Salmon contains high amounts of omega-3 fatty acids, which have been found to reduce the risk of depression and dementia and help improve mood. Their anti-inflammatory and antioxidant powers are thought to promote healthier brain cells and reduce brain deterioration related to ageing. Salmon contains a naturally high-occurring amount of vitamin D and has been linked to lower rates of depression. Other types of fish high in omega-3 fatty acids include tuna, mackerel, sardines, and herring.

Quick facts

Tutti™ apple

A tasty new apple

A new apple, Tutti™, was launched to growers in February 2023 at the Fruit Logistica trade show in Berlin. With a sweet taste and lightly crisp and very juicy texture, it is expected to excite consumers when it hits supermarket shelves in about five years' time.

The result of a transglobal partnership

The Tutti™ brand apple is the first variety commercially released from the Hot Climate Partnership, a collaboration between New Zealand and Spain focused on breeding new apples and pears for warming climates. The Partnership was established in 2002 by Plant & Food Research in New Zealand and the Institute of Agrifood Research and Technology (IRTA) in Spain with Catalonian grower association Fruit Futur. VentureFruit™ joined in 2019 as the strategic commercialisation partner.

Bred for climate resilience

Fruit from traditional varieties grown in high temperatures can have low red colouring, sunburn, soft flesh textures and higher-than-average incidence of storage disorders. Tutti™ is the first variety from the Hot Climate Partnership, with a full pipeline of selections of both apples and pears, specifically bred to combat the quality issues associated with warming temperatures, being evaluated and tested. These varieties will help traditional growing regions continue to produce fruit as the climate changes, while also providing opportunities for new regions to grow apples and pears.

New Zealand heritage with Spanish roots

The cross that resulted in 'HOT84A1' was made in New Zealand in 2002 by Plant & Food Research breeders, who sent the seeds to IRTA in Spain. The resulting trees were evaluated in Catalonia, where temperatures can regularly reach 40°C in summer.

An apple for everyone

The name Tutti translates to 'everyone' or 'all together' in Italian. This concept reflects the Hot Climate Partnership, which is delivering better solutions for growers, consumers and retailers. The brand tagline, 'love every bite', promises to meet the test of a great apple – how it tastes.

Tutti™ is open for licensing to all growers, fresh produce sales and marketing companies, and plant nurseries. **www.tuttiapple.com**

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.

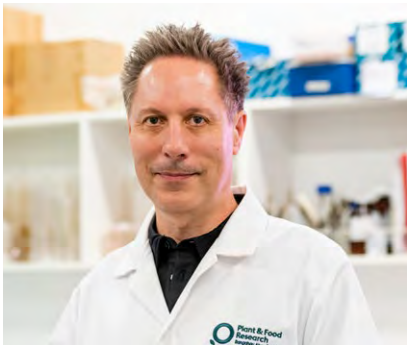
Plant & Food™ Research
Rangahau Ahumāra Kai

A smart green future. Together.

Every day we have 1000 people working across Aotearoa New Zealand and the world to help deliver healthy foods from the world's most sustainable systems. Here's what a smart green future together means to them.

A smart green future together has been gifted the Māori translation by our Māori strategy, partnerships and enterprise team. This translation is "He ao mātua, He ao manea, He ao tūroa". To me this translation is important to help connect our vision to our Māori partner organisations. In practice, it means a future for all, that is "matua" (prosperous), "manea" (clever), "tūroa" (long standing).

TE AUE ADDISON
Principal Advisor Māori



A smart green future together captures aspirationally where we as Plant & Food Research need to direct our future research and development. To survive on this planet, we need sustainable food production that contributes positively environmentally and socially, while at the same time being delicious, nutritious and healthy. This represents significant challenge, and requires smart thinking and smart technologies. The only way we can achieve this is by working together effectively, with ourselves, as well as with our local and global partners and communities.

JOLON DYER
Group General Manager, Science Services

A smart green future together, for me, is about our people applying their scientific expertise to overcome climate and environmental challenges and develop sustainable food production systems from our precious land that will grow nutritional food, not only for us today but for generations to come.

LIVERPOOL ZHANG
Relationship & Development Manager, Greater China

To me a smart green future means putting the healthy future of mankind and the planet ahead of profit.

STEVEN OWEN
Research Orchard Manager, Te Puke

For me, a smart green future together means having sustainable systems that are able to better adapt to changing climates and consumer preferences. It is about conserving our treasured natural assets to enable a greener tomorrow for future generations. By using the latest technologies, we can make smart choices with faster turnaround to help us adapt to change and meet new demands. So we can work towards a zero waste goal with the help from science and technology where we fully utilise our harvests from land and sea.

AMALI THRIMAWITHANA
Bioinformatician, Molecular & Digital Breeding

A smart green future together gives more to the world than it takes. Together is the way we enable a smart green future. Together is being values led to bring all of our unique talents and perspectives to our mahi, and to value the differences and potential of others. Together is achieved through showing respect, generosity and care for others to build strong collaborations and an environment where we can be our most innovative. Together means always looking for a better way and seeking out the knowledge and ideas of others. Ehara taku toa i te toa takitahi, engari he toa takitini. Success is not the work of an individual, but the work of many.

MARK McSHERRY
Organisational Development Leader

THE NUMBERS

14 sites across New Zealand as well as offices in Australia and the USA

1000
total staff

765
science staff

421 ha
research farms

We believe our science can make the world a better place. That by working together, we can create a smart green future for Aotearoa New Zealand and the world.

We invest in our people, our facilities, our information systems and in future science. We believe that these are vital parts of creating an organisation that delivers world-class science.

We know our science can only make a difference if it is applied outside the lab. We build relationships with customers and partners, including with Māori organisations, to find the best ways for our science to help their businesses grow.

We then share our knowledge and skills, so that our customers, our partners and Plant & Food Research itself receive fair value from the results of our science. We provide R&D services for those that need it and create pipelines of new technologies for commercialisation, either directly by us or in partnership with others.

For us, a smart green future means we use all available knowledge to produce healthy, nutritious food from the land and sea, while ensuring we protect our environment and create opportunities for future generations.

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

$43.1M
strategic funding
Government investment allocated directly to each Crown Research Institute

$15.0M
contestable
Government investment allocated through competitive bidding

$63.2M
royalties
Commercial return from plant varieties and IP

$58.6M
commercial
Direct investment by customers

$4.5M
other
All other income sources

For the year ending 30 June 2022

Our strategy will:

Enable New Zealand to build ...

A smart green future. Together.

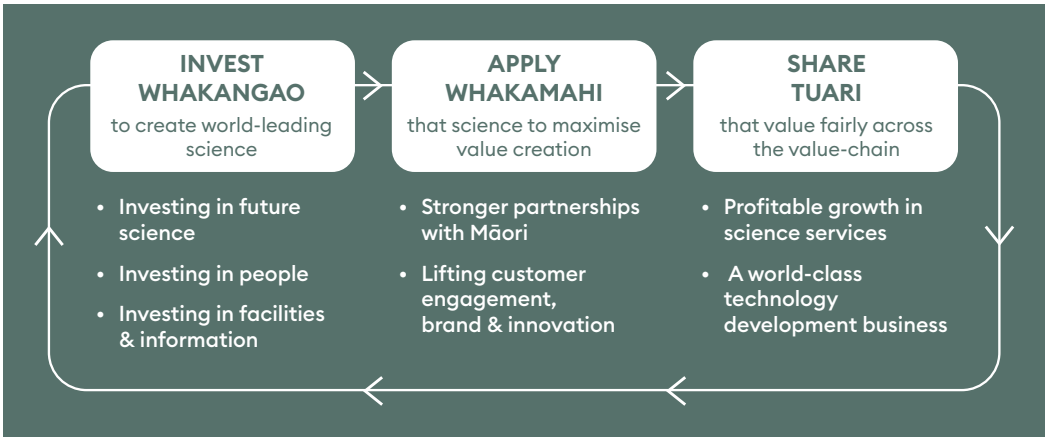
... by achieving our mission of ...

Creating the world's most sustainable food systems

... with science focused on 6 themes ...

Healthy ecosystems	**Positive foods**	**Aotearoa provenance**
Smart food systems	**Climate resilience**	**Full bioresource utilisation**

... underpinned by a business framework ...



... guided by our values ...

Mana tangata
We contribute our unique talents and perspectives

Manaakitanga
We show respect, generosity and care for others

Whai māramatanga
We always look for a better way

Science New Zealand Awards recognition

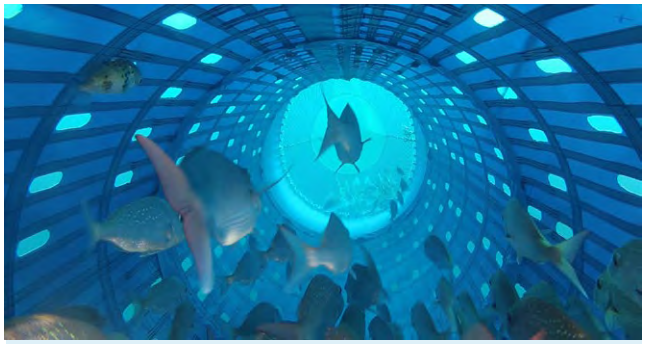
The Science New Zealand Awards, held at Parliament in December 2022, honoured a number of Plant & Food Research/Rangahau Ahumāra Kai scientists.

Dr Daryl Rowan, a former Principal Scientist and Science Group Leader, achieved the Lifetime Achievement Award. Dr Rowan, now an Honorary Fellow of the Biological Chemistry & Bioactives Group, has over 40 years' research experience and has played a pivotal role in developing metabolomics capabilities within Plant & Food Research.

The multi-disciplinary 'Filling the Void' project received the Team Award for their work in laying the foundation for a new breeding programme for Aotearoa-New Zealand. Their goal was to develop a novel berry that would combine the commercial benefits of blueberries with the colour-filled flesh of bilberries. The team made real progress in understanding the genetics and chemistry of these berries and created new hybrid plants.

Dr Rebecca Bloomer, who received the Early Career Researchers Award, leads Plant & Food Research's medicinal cannabis breeding and germplasm research. She also provides expert knowledge to identify the role of epigenetics in delivering resilient Plant & Food Research potato varieties, and is making a significant contribution to the 'The Flowering Crisis: Confronting a changing climate's threat to New Zealand's tree crops' project.

Dr Daryl Rowan, a former Principal Scientist and Science Group Leader, achieved the Lifetime Achievement Award.



Taking successful sustainable fishing technology to the world

A New Zealand fishing technology that's better for the environment, significantly reduces by-catch, and improves the quality of the fish captured is about to be fully commercialised and taken to the world.

The Modular Harvesting System (MHS) has already attracted international interest with research trials in The Netherlands looking at the benefits of the technology in a flatfish fishery, with a particular focus on survivability of the fish. The MHS system is designed to allow specific sizes and species to be targeted while increasing the survivability of small fishes and non-target fishes. The environment allows fish to control their own swimming in the net and arrive on deck less stressed and in better condition.

MHS was initially designed by Plant & Food Research and developed by Precision Seafood Harvesting (PSH) under a 2012 Primary Growth Partnership programme between the Ministry for Primary Industries (MPI), Sealord Group Ltd, Moana New Zealand, and Sanford Ltd. The development of the MHS is being funded by PSH and MPI.

Science organisations combining to plot a path to net carbon zero

Eight government-owned science organisations, including Plant & Food Research, have joined forces to accelerate the reduction of their greenhouse gas emissions.

"Together the eight organisations employ about 4300 staff and have offices and research facilities in more than 50 locations around the country," says Plant & Food Research's Chief Sustainability Officer, Dr Roger Robson-Williams.

Climate Change Minister, Hon. James Shaw, said he was delighted that the Crown Research Institutes and Callaghan Innovation had come together to work out how we can cut emissions in the government's science sector.

Kiwi technology — changing how we detect disease

Kiwi start-up Scentian Bio, which is developing a ground-breaking technology that can detect human diseases, such as tuberculosis and malaria, was awarded a $US 1.7 million grant by the Bill & Melinda Gates Foundation in November 2022.

Scentian Bio is harnessing the power of insect olfactory receptors to develop novel biosensors that can detect volatile organic chemicals (VOCs) – or more simply, smells, in liquid and air. Scentian Bio's Chief Technology Officer, Dr Andrew Kralicek, spent 19 years at Plant & Food Research determining how smell receptors in insects work and how they can be used to create a biosensor that can detect and identify odours.

"We are creating the world's first camera for smell, by detecting the pattern response from an array of olfactory receptors on an electronic chip," Dr Kralicek says. In this way we will democratise VOC sensing beyond the research lab, and put it into the hands of everyday people."

New research to future-proof New Zealand's wine sector

The new Experimental Future Vineyard (EFV) facility, based in Blenheim at the New Zealand Wine Centre/ Te Pokapū Wāina o Aotearoa and operated by Plant & Food Research, will help enhance the supply of high quality grapes for New Zealand's wine sector into the future. The Centre will provide a unique resource for research into wine grape production and support the productivity and quality aspirations of the New Zealand wine sector by developing new growing practices with improved environmental outcomes.

"We're excited to be a part of Te Pokapū Wāina o Aotearoa," says Dr Damian Martin, Science Group Leader Viticulture and Oenology. "We know climate change will add to challenges facing wine production in New Zealand, with warmer days and more insect pests and diseases able to establish here."

Development of the new $3.3 million EFV at Te Pokapū Wāina o Aotearoa is supported by the Ministry of Business Innovation and Employment's Provincial Growth Fund. Plant & Food Research will operate the facility and develop research programmes in collaboration with the Marlborough Research Centre, national and local government, and the New Zealand wine industry, as well as providing student opportunities through the Nelson Marlborough Institute of Technology (NMIT) Te Pūkenga.

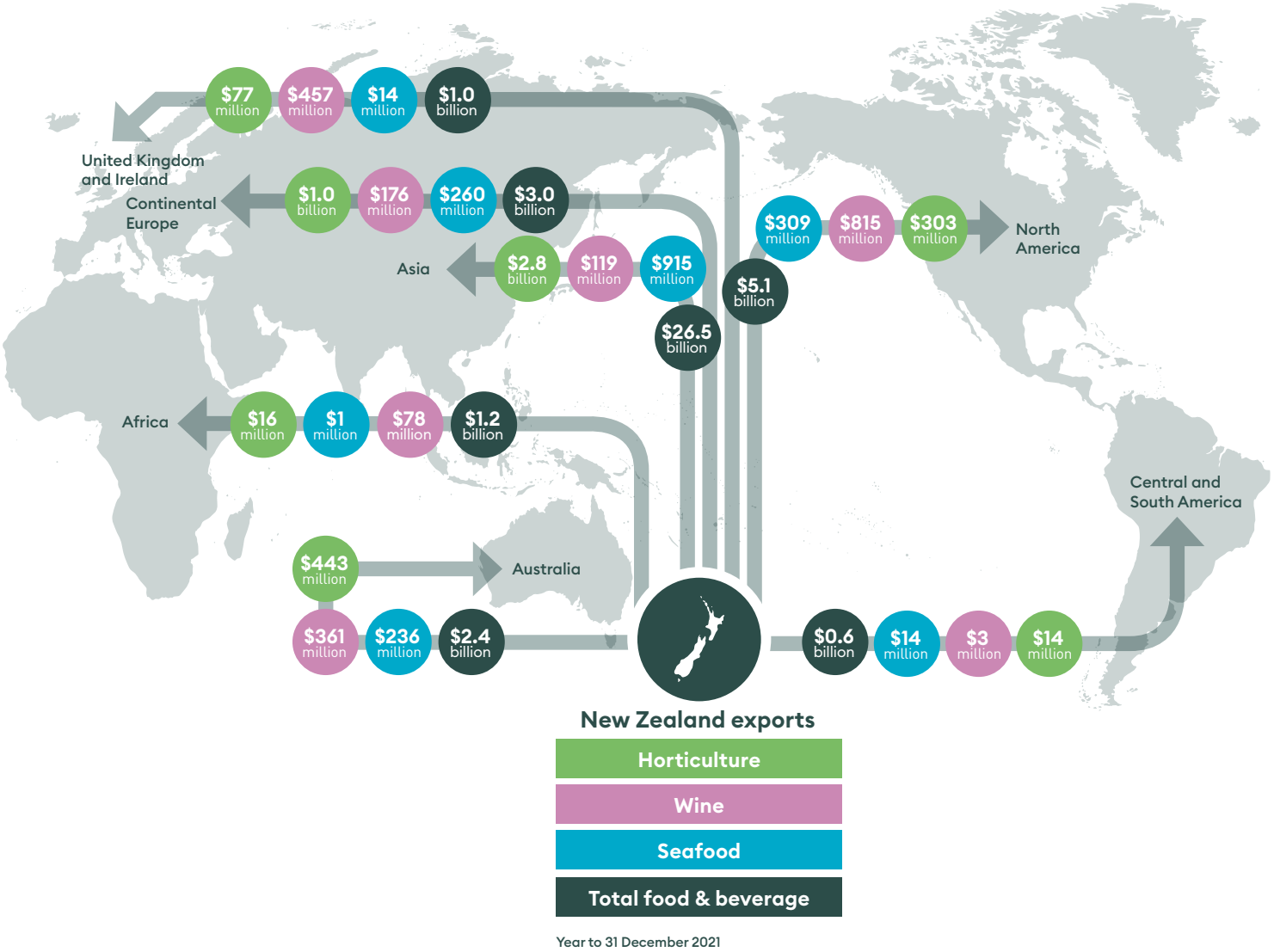
New funding focused on improving fruit production

Plant & Food Research received New Zealand Government funding in 2022 for three new Endeavour Fund Smart Ideas projects focused on improving fruit production through better flowering and pollination.

The 'How many flowers' project will look at flowering in crop plants. Flowering is essential for fruit production, and climate change is anticipated to drive extreme variability in flower numbers. The two-year project 'Beekeeping outside the box' will look to redesign beehive architecture and handling to improve pollination efficiency. The three-year 'Sustainable, intelligent fruit production through novel nozzles for autonomous pollination' project will focus on designing new nozzles that can be incorporated into autonomous robotic systems to replace insect pollinators in the orchard.

Our sectors

In 2021, New Zealand exported more than $40 billion of food and beverage products, 52% 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.



Year to 31 December 2021

Scigest

podcast-sized servings of digestible science

The Scigest podcast, hosted by scientists from Plant & Food Research, delves into our science and the fascinating stories of the people behind the science. Discover a diverse range of stories covering everything from a gene discovery for cloning to the science of soil health.

Listen on our website plantandfood.com/welcome-to-scigest or subscribe via your favourite podcast app.

A smart green future. Together.

Plant & Food™ Research
Rangahau Ahumāra Kai

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