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NEW ZEALAND PLANT PRODUCERS INCORPORATED

NZ Plant Producers

PLANT PRODUCTION SCIENCE

Bringing you the latest plant science from New Zealand and around the world.

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In Issue five we look at Global Plant Breeding and Genetic Innovation.

Contents

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A special thanks to **Kiwiflora International** for supporting this issue.

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Using science and innovation in your plant production?
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New genetics for a changing world

Welcome to this edition of Plant Production Science. The plant production industry plays a vital role in introducing improved plants for our primary industries, landscapes and urban environments.

New plant genetics hold the promise of creating more productive, pest and disease-resistant crops, and better-adapted, invasive-free varieties.

Offshore breeding programmes are the source for much of this innovation, accessing large germplasm resources and harnessing the availability of modern genetic tools. Traditional breeding approaches include ploidy manipulation, mutation breeding and interspecific and intergeneric hybridization to create new varieties. Advanced breeding technologies including gene-editing are set to revolutionise plant breeding in the future.

Our primary exports depend on imports. We've mapped the sources of live plant and bulb imports, offering new insights into the value of plant imports to New Zealand. Globally, the Netherlands dominates flower bulb production, supplying 70% of the world's bulbs, including tulips, lilies, and daffodils. New Zealand has a significant bulb export market, supplying the northern hemisphere with counter-seasonal supply of bulbs for the cut flower market.

Dwarfing rootstocks have allowed for higher planting densities in orchards which has reshaped apple production in New Zealand. New rootstocks are being trialled in other crops such as cherries and avocado.

New berry crops could create different market opportunities, while in the Far North specialty coffee is being explored as a high-value new industry.

Our primary exports depend on the import of new plant genetics.

Disease-resistant plant varieties prepare industries against pathogens and reduce fungicide reliance. In this issue, we look at new disease resistant grapevines and box (Buxus).

New Zealand's domestic plant breeding programmes make significant contributions to the development of new cultivars. Kiwiflora International explains the process involved in developing and commercialising new varieties here and offshore.

Regional urban afforestation plans focus on increasing canopy cover to mitigate climate change impacts. New Zealand lags behind in importing and trialling new cultivars, a process slowed by strict quarantine measures. Australia's street tree trials may herald new opportunities for New Zealand. We talk to Flemings in Australia about some of the newer cultivars being trialled there and take a sneak peek at exciting cultivars being bred overseas for this purpose.

Invasive species are a concern to our industry and customers, and overseas breeders are developing sterile plant varieties to replace the weediest species.

Finally we look at modern gene-editing techniques, new technology to accelerate plant ageing and high-throughput sequencing technology to screen for diseases in quarantine.

Kathryn Hurr, NZPPI.

Breeding for global markets

New Zealand is part of global fruit marketing programmes, producing counter-seasonal supply of horticultural crops to the northern hemisphere.

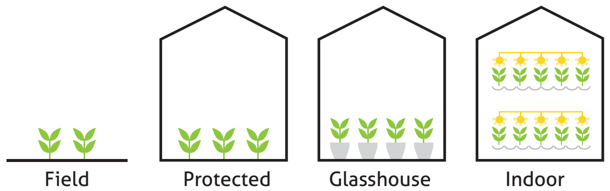
Commercialisation models using proprietary varieties are becoming more and more prevalent. Control over the volume and quality of supply, and investment in sophisticated 'branding' and retail programmes ensure a good return in market value. In turn the breeder receives royalty revenue to reinvest in the development of new and exciting premium varieties.

Older open-source varieties will struggle to remain competitive, as globalisation is having a big impact on what people are growing and how. Increasingly, international breeding companies are dominating the landscape, and this trend is reflected in the number of grants under the Plant Variety Rights (PVR) Act.

A review of recent PVR statistics for New Zealand's top 10 horticultural export crops show a trend towards licensing plants bred overseas, with 67% of granted applications and 85% of new applications filed, up from 77% of applications filed in 2019/20 from offshore breeders. See Table 1.

Global breeding companies can leverage extensive genetic resources and significant investment capital to develop crop varieties tailored for diverse geographical regions. Taking advantage of broad genetic pools and advances in breeding techniques, they are breeding new varieties in different locations to optimise them for different growing climates, day lengths and so on. This enables them to license specific varieties to a range of growers around the world, controlling the volume of supply from different countries seasonally, and enabling an almost continuous supply to the market.

As well as this shift, we are also starting to see a change to crop production methods driving the need for new plant genetics. The berry fruit sectors are undergoing a major renaissance in New Zealand and overseas, moving from outdoor growing to undercover cropping. In strawberries, this has negated the need for soil fumigation between seasons and protects crops against adverse climatic events. It is also easier on staff managing plants and picking at bench height. It has changed the cost structures for the industry, as infrastructure is more expensive. New strawberry genetics have been imported that are more suitable for indoor growing, and overseas breeders are amid another big step-change expanding from 'short day' genetics to day-length neutral and ever-bearing strawberries which in the right growing conditions could flower and fruit all year round.



Increasing protection of crops has changed the genetic targets for breeding.

Global warming and the degradation of the environment are two of the biggest problems facing the world now. While we deal with the causes of these, we still need food plants that will survive with more heat, less water, less pesticides, and less fertilisers. For example, in outdoor horticultural tree crops, marketing companies are working with scientists and breeders to develop variants such as hot-climate apples, and low-chill cherries, which will be better adapted to a hotter future climate and production can expand into non-traditional growing areas.

Table 1: Horticultural export and Plant Variety Rights statistics.

Top 10 horticultural export crops 2023/24		FOB export value x $000	PVR filed (but not yet granted)		PVR Granted		Plant Variety Rights	
			NZ breeder	Offshore	NZ breeder	Offshore	NZ breeder	Offshore
Kiwifruit (not incl kiwiberry)		2,703.0	3	10	11	2	14	12
Wine (grapes)		2,100.0	Not typically protected by PVR					-
Apples (est)		939.9	16	37	38	50	38	52
Onions		184.8	0	2	0	3	0	5
Processed Peas		166.9	4	4	0	6	4	10
Potatoes (fresh & processed)		134.5	1	36	15	52	15	88
Stone fruit	Cherries	92.6	0	28	2	10	2	38
	Other	2.3	1	8	26	24	27	32
Squash		55.1	Not typically protected by PVR					-
Berry fruit	Blueberries	47.7	3	17	17	53	20	70
	Other	1.2	0	17	14	54	14	71
Processed Beans		46.8	Not typically protected by PVR					0
			28	**159**	**123**	**254**	**134**	**378**
FOB export value 2023/24		**$6,474,800**	**15%**	**85%**	**33%**	**67%**	**26%**	**74%**
Total horticultural exports 2023/24 approx.		**$7,110,000**						
% of export value from top 10 export crops		**91.1%**						

New Zealand must invest in improving existing and adoption of new plant genetics to adapt to these changes in the global market and the environment. If we can't or don't access the new genetics, we fall behind, existing varieties become harder to grow, use more resources than our competitors, and are less productive than newer varieties. As well as being less profitable, older varieties may no longer meet the evolving preferences of our international customers.

We can't afford to focus just on the crop species which are important today, and need to invest in new crops, diversify and build new markets.

Importing fruit crop germplasm is a lengthy and expensive process, involving quarantine, stock build-up, extensive trials across diverse locations, and ensuring the breeders intellectual property is protected. These steps are necessary before commercialisation but demand significant investment and foresight. We need to be importing now what we will want to be exporting in 10-15 years.

The New Zealand plant imports system has been constrained over the past twenty years and has become difficult and a lot more expensive. The slow pace of import health standard review has prevented timely importation for important species such as avocado, hops and citrus, and germplasm of many other smaller and emerging crops such as pears, persimmons, passionfruit, blackcurrants and garlic can't currently be imported at all. This is hampering the ability of the sector to offer new varieties to the market, reduce costs and adapt to pest and disease pressure.

There are more people engaged in plant breeding in universities, research institution, private and commercial, than ever before creating a world of opportunities. Right now, we need to ensure we can have greater access to germplasm from around the the world.

Louisa van den Berg,
BLOOMZ New Zealand Ltd.

The importance of new genetics

Innovation is at the heart of horticultural success, helping industries remain competitive in the face of increasing costs, climate change, and changes in global market forces and consumer preference.

> Doubling exports seems unattainable without the import of improved plant genetics.

In recent years, the vision of doubling New Zealand's export value has gained significant momentum, with ambitious roadmaps such as the Aotearoa Horticulture Action Plan and the Ministry for Primary Industries' (MPI) Double Export Value Plan. These all highlight the importance of innovation but underplay the pivotal role that plant genetics play in achieving this goal.

Doubling exports seems unattainable without prioritising the need for importing improved genetics.

While domestic breeding programmes in apples, kiwifruit, hops, pastoral grasses, and radiata pine provide a solid foundation, even domestic breeding programmes benefit from the injection of new germplasm. Integration of international germplasm underpinned by advanced breeding technologies is critical to achieve momentum in an increasingly competitive global environment.

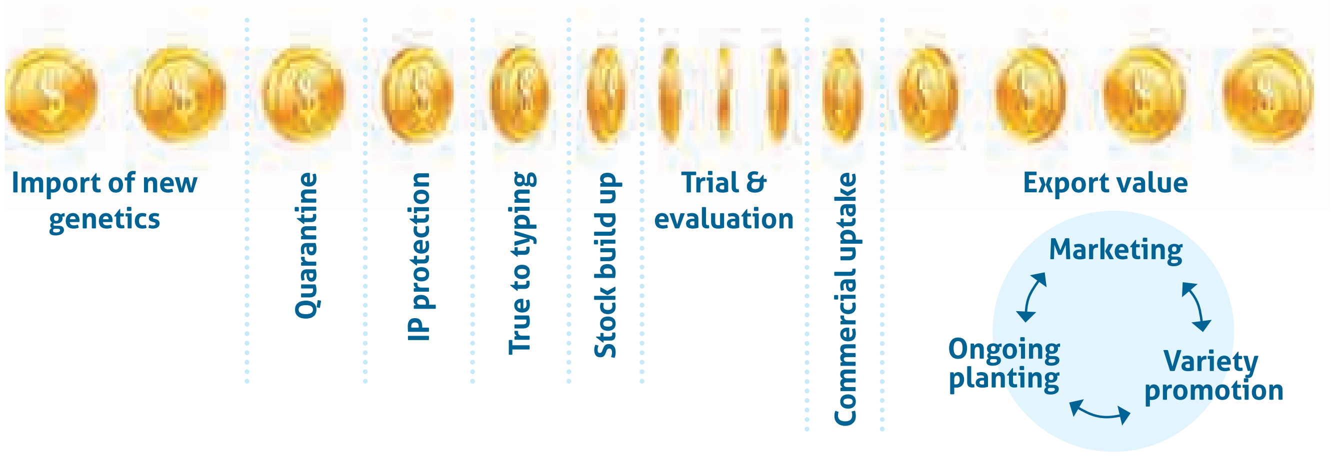
Most of New Zealand's other horticultural crops and nearly all Greenlife species rely on offshore breeding programmes.

Plant imports precede the ability to export new varieties, so they are two sides of the same coin. In New Zealand, strict quarantine requirements to prevent the introduction of pests and diseases add to the lead times and high costs associated with importing new genetic material.

Some estimates suggest it can cost up to $100,000 to import new varieties through the MPI Level 3B quarantine system.

Not all imported varieties are suitable for New Zealand's unique growing conditions. Factors such as UV intensity and other local environmental conditions can affect the performance of new varieties, so only about 20% of imported varieties are ultimately commercially adopted.

Plant imports precedes the ability to export new varieties – they are two sides of the same coin.



Coffee – *an emerging new industry*

Growers in the Far North have been trialling coffee as an alternative crop and are exploring the potential for a specialty coffee bean industry.

Coffee berries harvested from New Zealand grown trees in the Far North. Photo courtesy of Tony Hayward.

Tony Hayward has cultivated five Arabica varieties among his avocado plantations over the past 14 years and sees an enormous potential in areas with optimal growing conditions, such as Kaipara and Mangawhai North. New Zealand's low latitude growing conditions are comparably advantageous to those found at higher altitudes, producing high quality beans rich in carbohydrates due to the long ripening season.

Recent tastings (cupping) of New Zealand-grown coffee beans achieved a high score of 82 points on the sensory scale. This aligns with the specialty coffee criteria, which requires a score of 80 to 100. There is an opportunity to improve the cup score through processing improvements and Tony is hoping to achieve a score of 90 at the next cupping test in 2025.

Arabica produces the most sought-after coffee, especially from cultivars belonging to the Bourbon or Typica lineages and their hybrids. Both lineages are grown in New Zealand, but for the industry to flourish, a broader genetic diversity is needed through the introduction of new genetics.

The fledgling New Zealand industry now needs to undertake extensive growing trials to see where plants can be grown most productively. To do this, they need to import new genetics and scale up the production of young plants.

A major advantage for New Zealand is freedom from coffee specific pests and diseases. At present, coffee can only be imported as seeds for sowing from a restricted number of countries. In part this is due to the risk of introducing the coffee berry borer (*Hypothenemus hampei*), which is a critical threat to major coffee-producing regions around the world. The New Zealand Coffee Association will be requesting a review of the Seed for Sowing import health standard to approve more countries for export and any required updates to measures that manage pest and diseases.

Trials of new varieties, including dwarf varieties, are underway in Australia through the International Multilocation Variety Trial (IMLVT) network, supported by World Coffee Research (WCR). This initiative is vital for preserving coffee genetic resources amidst the threats posed by climate change and pest pressures. The New Zealand Coffee Association aims to reach out to the WCR to enable a collaboration around new varieties for trial here.

Research published this year on the genome and population genomics of Arabica shows modern coffee cultivars have a low genetic diversity due to their allotetraploid origin and strong bottlenecks during its history. The low genetic diversity means that Arabica is highly susceptible to many plant pests and diseases.

The Bourbon lineage dates back to a single Arabica plant which was cultivated on the island of Bourbon (presently Réunion) in year 1720. The Typica group originated in Southeast Asia from seeds introduced by the Dutch, and from there, only one plant was used to establish Arabica cultivation in the Caribbean in 1723.

The collaborative effort among growers, researchers, and industry experts will be key to achieving sustainable growth in this emerging sector.

Tony Hayward, Kauri Coffee.

New berry crops

Aroniaberry and honeyberry are emerging new berry crops, with breeders overseas and in New Zealand exploring their commercial and health potential.

Aroniaberry – a new fruit crop being developed by Dr Mark Brand at the University of Connecticut.

The black fruits of *Aronia melanocarpa* contain five times the antioxidants (anthocyanins and flavonoids) found in cranberries or blueberries. Trials in Central Otago have shown the region's climate is ideal for *Aronia* cultivation, with significant diurnal temperature fluctuations, cold winters promoting spring blooming, and high UV exposure enhancing anthocyanin levels.

The genus is native to the eastern United States, but Eastern European and Russian breeders had significant breeding programmes in the late 1800s and early 1900s. In Russia, a breeder developed an intergeneric hybrid between *Aronia melanocarpa* and *Sorbus aucuparia*, creating larger fruited cultivars. At the University of Connecticut, Dr. Mark Brand is exploring the complex ploidy genetics of *Aronia* and investigating the intergeneric origins of larger-fruited varieties.

The University is home to the world's largest Aronia germplasm collection, comprising 106 wild accessions from across the United States and additional specimens from Ontario, Canada. Dr Brand's work aims to expand the genetic diversity of this emerging fruit crop and support its future breeding potential.

Honeyberry (*Lonicera caerulea*) is another berry crop high in antioxidants being developed for New Zealand's domestic market by a New Zealand Tree Crops team headed by Robyn Hee.

Wild honeyberries are native to western Russia, northern China and northern Japan and are grown commercially in Canada, Japan and Russia.

Breeding programmes at Oregon State University, Corvallis and the University of Saskatchewan have developed commercial varieties, selected for fruit flavour, size, ripening times and mechanical harvestability. NZ Tree Crops looked at the viability of importing these for trials in New Zealand, but the high cost of quarantine led them to start their own breeding programme from seed imported from Corvallis.

Honeyberry (*Lonicera caerulea*) – a new crop being developed by NZ Tree Crops.

Starting with open-pollinated seed from 25+ accessions of Russian and Hokkaido genetics, the team noted a lot of genetic diversity in the 1st generation of plants. The flavour is not uniform, with the best flavours ranging from intense blackberry/boysenberry, peach, to low acid-chocolate/cherries/pinot.

Fewer than 1% of seedlings have been selected for 'parent stock' and used to develop the next generation of plants which are better adapted to local soils and climate.

For commercial production, a stable of varieties are required for cross-pollination and to maximise yields. More options available for home garden, where high yield are certain fruit characteristics are not so critical, but flavour and berry size might be more important. NZTCA plan to launch some cultivars directed at the home gardener market soon, while independent breeders are still making progress with 3rd generation NZ material.

Eric Cairns,
New Zealand Tree Crops Association.

New Zealand's national germplasm resources

Crown Research Institute Plant & Food Research (PFR) holds 118 collections of plant germplasm for breeding and conservation purposes, including two Nationally Significant Collections.

Photo credit: Plant & Food Research.

The collections cover 65 crops, totalling more than 40,000 individuals. Some are held as whole plant collections, such as kiwifruit and apple, and some as seed, such as cereals and pea.

The two Nationally Significant Collections are the Arable and Vegetable Germplasm collection and the Fruit Crop Germplasm collection. These hold plants mainly sourced from overseas in the mid-20th century, and some of the plants within the collections are unique within New Zealand.

Plant & Food Research's breeding collections contain large numbers of individuals selected with traits of interest for breeding programmes. Most breeding programmes are conducted with a breeding partner, which has rights to the outcomes of that breeding programme.

In some crops, Plant & Food Research has a single, exclusive breeding partner, in others, there are multiple breeding programmes underway in parallel, with individual partners granted exclusive rights to selections bred with specific targets and parent choices.

Some collections have strict limitations on their use, and PFR are not always able to share plants with third parties. They are currently working through the collections to ascertain the freedom to operate for each plant. Due to the age of the collection, this is a time-consuming process that requires analysis of scientists' records at the time of collection, mostly still held in paper files, to determine the legal rights for sharing.

Plant & Food Research also invests in developing new ways to hold material in long-term storage, such as tissue culture and cryopreservation.

Fruit	Cereals and Vegetables	Other
Blackcurrant	Barley	Manuka
Blueberry	Oats	Ornamentals, including Gentian
Rubus	Triticale	
Snowberry	Wheat	
Almond	Forage brassicas	
Apple		
Citrus	Onions	
Dragonfruit	Potatoes	
Hops	Peas	
Kiwifruit	Kumara	
Pears		
Apricot		
Cherries		
Plums		
Peaches and nectarines		

Emma Timewell,
Plant & Food Research.

New Zealand plant breeding

Kiwiflora International is an ornamental plant breeding company. We also represent other plant breeders in New Zealand and showcase their plant inventions to the world.



Clockwise from top:
Kiwiflora International Dianthus Angel of Peace, Magnolia Genie and Lomandra White Sands.

How does this happen? The first part of this process is to assess the plant invention and make a commercial judgement about its worthiness and possible place in the world market. We have to decide whether this particular plant is going to succeed in this highly competitive market.

The second step for Kiwiflora International involves navigating the often lengthy and complex logistics required to make a specific genus and species commercially available. As a third-party genetic supplier, Kiwiflora International operates independently of major commercial plant breeders like Dümmen and Syngenta. This means we must establish a reliable supply chain, starting with tissue culture initiation and extending to the delivery of high-health vegetative material. These materials must come from a trusted and accessible source for major growers in the USA and Europe. This process is neither quick nor inexpensive, but it is essential to successfully commercialise the plant.

To put this into perspective, a new plant that we breed today may take 10 years to get to market in commercial numbers. Kiwiflora International funds this initial investment into research and development and the investment in protection via Plant Variety Rights, Patents and Trademarks. Kiwiflora International has always invested in its breeding programmes, focusing predominantly on *Dahlia* and *Dianthus*. These programmes are headed by Dr Keith Hammett, a collaboration that has seen the successful commercialisation of the Mystic series of *Dahlia* and Scent from Heaven *Dianthus*, with others in the pipeline.

In addition to our own breeding, our portfolio of plant material is a diverse one, to say the least. It is made up from the breeding work of the many extremely keen plant people that New Zealand is lucky to have. Traversing such diversity as the award-winning *Magnolia* breeding of Vance Hooper, epitomised by the magnificent *Magnolia* 'Genie', to the chance nursery find of *Uncinia* 'Everflame' (Belinda's Find), a variegated selection of the NZ native *Uncinia rubra* that a sharp-eyed nurseryperson spotted in a batch of seedlings. Do not underestimate the chance find in a mass of seed or even vegetatively derived young plants. Keen eyes and a knowledge of what is the norm and what is different can be the start of a new cultivar.

What happens next is the make-or-break part; establishing the DUS: Distinct Uniform and Stable. DUS is the mantra of Plant Variety Offices around the world. The distinct part is what originally caught your eye, but the uniform and stability criteria take work to ensure these two critical aspects are achievable. DUS also applies to progeny from an established breeding programme, where the expected or potential outcomes from crossing selected parent plants may align with your goal, but more often, the true results are surprising and unexpected.

This is where breeders in New Zealand have an advantage over the thousands of plant breeders working for large corporate plant breeding companies. Back in the glasshouses of the big breeding companies, the employed plant breeders work in small increments to gradually inch toward a desired goal, which their extensive marketing departments then sell to the world as the latest and greatest, dare I say, it (yet another) pink *Petunia*, 'outperforming' all those Pink *Petunia* from last year's release.

An advantage for New Zealand plant breeders is that we have the luxury of working in isolation, in a country located at the bottom of the world map. Breeders are often working with an unbroken plant genetic lineage that can be traced back to Victorian England or with plant material unheard of in those mainstream markets of Europe and the USA.

Hammett x Kiwiflora = Mystic Dahlia in France.

Unexpected outcomes or chance benefits often happen when you are not following a path of incremental improvements, sometimes with an outcome or a benefit that we are not initially aware of until it is trialled in another climate zone.

Lavender 'Thumbelina Leigh' is a case in point where plant breeder and lavender expert Elsie Hall noticed a small compact lavender emerge from her programme for breeding lavender to improve vigour and increase oil content. Trialling 'Thumbelina Leigh' in Europe showed that it flowered significantly earlier in Europe than any other known *Lavandula angustifolia* type, making it a desirable and very marketable plant. It is now sold, by the millions, in small containers as tabletop ornaments to help welcome spring into European homes emerging from the rigours of winter.

Plant breeding has had a long and successful history in New Zealand. However, most of us have now seen too many sunsets and plant breeding is a long game. The next generation, the future New Zealand plant breeders, are TBD (to be determined). I would encourage anyone with an interest in plants to "give it a go Kiwi".

Malcolm Woolmore,
Kiwiflora International.

Profit from your unique plant varieties with the global marketing expertise of Kiwiflora International.

Kiwiflora International presents an impressive history of safeguarding, overseeing, and cultivating sustainable global royalty income from plant inventions. We advocate for you, the plant breeder, guiding the journey from selection to market visibility.

Our strong partnerships within a global network allow us to maximise marketing opportunities for your distinctive genetic varieties.

KiwiFlora International

Talk to us about globally marketing your unique plant varieties. Phone Malcolm Woolmore 021 906 295.

www.kiwiflora.com

Testimonials from New Zealand Plant Breeders available on request.

New rootstocks for disease resistance

New rootstocks with better disease resistance and environmental tolerance have the potential to improve productivity of New Zealand avocado, apple and cherry orchards.

Rootstock breeding is a long-term investment, with new varieties taking around 10 years to develop and evaluate. During this time, researchers assess each rootstock for its productivity, yield, vigour, fruit size, and suitability for grafting with different varieties.

Avocado

Five new avocado rootstocks imported into New Zealand in 2022 are undergoing field trial and evaluation, with the hope of significantly improving grower returns. Among these are four advanced rootstocks from the University of California Riverside (UCR) and a rootstock from Haskelberg Nursery in Israel. These rootstocks have demonstrated resistance to various *Phytophthora cinnamomi* populations and show potential for improved productivity under different soil and climatic conditions.

New avocado genetics in plant quarantine (photo courtesy of Brad Siebert).

The use of superior genetics is crucial for many primary industries, and avocado farming is no exception. Programmes around the world are working to develop cultivars with enhanced traits. New Zealand has benefited from the introduction of superior avocado rootstocks like Dusa and Bounty, which were imported in 2005-2006 and have since improved orchard health and yields. Domestically, there is also interest in identifying promising genetic material, such as a rootstock selected from a New Zealand orchard that is now showing commercial potential.

The integration of imported avocado genetics into local breeding programmes will help the sector stay competitive. Countries like South Africa, Chile, Israel, and the USA have already developed advanced avocado rootstocks, which are increasingly resistant to diseases such as Phytophthora root rot (PRR). The need for new genetics is particularly important given New Zealand's lower and more irregular avocado yields. The industry faces significant year-to-year swings in productivity, largely due to irregular bearing, and must address these issues to stabilize output. By importing and trialling new rootstocks, New Zealand avocado growers can improve productivity, access more consistent market supply, and enhance fruit quality.

Apple orchard.

Apple rootstocks.

Apples

Over the past 30 years, the apple industry has shifted to the use of dwarfing rootstocks, enabling higher tree densities and greater productivity. Now the focus is on greater resistance to diseases and environmental stresses.

The decision of which rootstock to plant is critical, as orchards may see several different apple varieties grafted onto the same rootstock over a 20-year period.

Developed by Cornell University, the Geneva rootstock series offers a range of advantages over traditional rootstocks. They're resistant to woolly apple aphids, which attack tree roots and can hide in the fruit, posing a phytosanitary risk for export markets.

Fire blight is another significant concern for apple growers, particularly in regions like Hawke's Bay where outbreaks have led to significant tree losses. Traditional rootstocks, such as M9, are highly susceptible to this bacterial infection which can cause tree losses of 5-10% during severe episodes. The introduction of fire blight-resistant Geneva rootstocks offers a potential solution to this problem.

The Geneva series are also resistant to *Phytophthora*. Wet ground conditions, such as those experienced during cyclone Gabrielle, can increase susceptibility to *Phytophthora*, a soil-borne disease that thrives in waterlogged conditions.

Apple replant disorder reduces the vigour of newly planted trees in soils previously growing apple trees and can persist up to 40 years. Soil fumigation has been used to sterilize the soil between plantings but this approach is increasingly unsustainable. Geneva rootstocks are tolerant to replant disorder, reducing the need for chemical interventions.

Eight different Geneva rootstocks are available in New Zealand, each at varying stages of commercialization. One of the most established is CG202, which has been in use for around 20 years. Two new rootstocks Geneva 41 and Geneva 11 are now being produced in commercial volumes through tissue culture, which could further accelerate the adoption of Geneva rootstocks in New Zealand orchards.

Cherry Rootstocks

The traditional cherry rootstock Colt produces vigorous trees but struggles with yield efficiency, prompting the need for new approaches to orchard management.

The Gisela series of cherry rootstocks are hybrids between sour cherry *Prunus cerasus* and wild cherry *Prunus canescens*. They offer dwarfing characteristics so growers can plant more trees per hectare to improve land use and yield efficiency.

Gisela® 6 and Gisela® 12 are currently in production and being trialled in Central Otago and Hawke's Bay orchards. Three other rootstocks, Gisela® 5,13 and 17 are still in post-entry quarantine.

Brad Siebert, Avocados NZ and Kate Marshall, Waimea Nurseries.

Pierce's Disease: Managing the risk

Paseante noir, a Xf resistant grapevine variety making wine with a similar taste to Zinfandel.

The introduction of Pierce's Disease-resistant grapevines could help protect New Zealand's viticulture industry in the event of a *Xylella fastidiosa* incursion.

Pierce's Disease, caused by the bacterium *Xylella fastidiosa*, represents a serious threat to New Zealand's viticulture industry. The disease obstructs the xylem vessels responsible for water transport in plants, leading to symptoms such as leaf scorch, stunted growth, and vine death within one to three years of infection.

The potential spread of *X. fastidiosa* and its vectors to New Zealand is a genuine concern. In California Pierce's disease costs the wine industry over $100 million per year.

This bacterium poses risks beyond grapevines, affecting a wide range of plants, including olives, citrus, and stone fruit. With an extensive host range of over 400 species, many of which can be asymptomatic carriers of disease, *Xylella fastidiosa* is particularly difficult to manage.

A Potential Solution: Resistant Grapevines

Over the past two decades, researchers at the University of California, Davis, have developed resistant varieties by crossing the common wine grape species, *Vitis vinifera* with *Vitis arizonica*, a wild grape from the southwestern United States that has natural resistance to Pierce's disease.

Through multiple generations of backcrossing with *Vitis vinifera*, hybrids have been refined to maintain over 90% of the genetic profile of traditional wine grapes producing quality wines from vines resistant to the disease.

Five disease-resistant grapevine varieties have been released to date, comprising three reds and two whites:

Red Varieties:

- **Camminare Noir:** 94% *Vitis vinifera* heritage including 50% Petite Sirah and 25% Cabernet Sauvignon, with the wine exhibiting characteristics of both.
- **Paseante Noir:** Similar to Zinfandel, is 97% *Vitis vinifera*, including 50% Zinfandel, 25% Petite Sirah, and 12.5% Cabernet Sauvignon.
- **Errante Noir:** Resembles Cabernet Sauvignon, is 97% *Vitis vinifera*, including 50% Sylvaner and 12.5% each of Chardonnay, Carignan, and Cabernet Sauvignon.

White Varieties:

- **Ambulo Blanc:** With 97% *Vitis vinifera* heritage, including 62.5% Cabernet Sauvignon, 12.5% Carignan, and 12.5% Chardonnay this variety produces wine comparable to Sauvignon Blanc.
- **Caminante Blanc:** Also 97% *Vitis vinifera* with the same mix of varieties as Ambulo Blanc in its heritage, this variety produces wine with flavour profiles reminiscent of both Chardonnay and Sauvignon Blanc.

Challenges and Next Steps

Introducing these resistant varieties to New Zealand requires regulatory approvals. As *Vitis arizonica* is not currently present in the country, approval from the Environmental Protection Authority (EPA) is needed before any plant material can be imported. Bragato Research Institute and New Zealand Winegrowers are currently exploring this pathway.

While the risk of an outbreak remains uncertain, taking proactive measures, including research, regulatory preparation, and industry collaboration, will help safeguard this sector.

Amy Hill,
Bragato Research Institute.

Blight resistant Buxus

New *Buxus* varieties have been bred by a Belgium nursery to be resistant to the fungal pathogen *Calonectria pseudonaviculata* (Buxus blight).

Buxus blight has had a devastating effect on *Buxus* topiary and formal hedges around the world, cutting a swathe through millions of box plants in Europe since the mid-nineties. The fungal spores are airborne and can survive in decomposing leaves for a year, making it almost impossible to eradicate. The disease first appeared in New Zealand in 1998 and spread rapidly around the country. The only control options are a restricted range of heavy-duty fungicides, not available to the home gardener unless they have a Growsafe certificate, so countless thousands of hedges have been removed and replaced with alternative species.

The blight resistant varieties have been developed through an intensive breeding programme at Herplant BV in collaboration with the Flanders Research Institute for Agriculture, Fisheries and Food. Herplant BV have a large collection of more than 200 Buxus species and cultivars and started a breeding programme in 2007. Using traditional breeding methods, different species of *Buxus* were hybridised and more than 10,000 seedlings were screened for blight resistance. Four selections are available under the brand name 'BetterBuxus®', each with distinct growth characteristics to fill different roles in the world of topiary and formal hedges.

One of the four hybrids, *Buxus* 'Renaissance' is being bulked up for release to the New Zealand market in 2025. The other three cannot currently be imported as they are hybrids with *Buxus sinica* and *B. bodinieri*, which are not on the MPI Plants Biosecurity Index.

BetterBuxus at Herplant BV, photo courtesy of Kiwiflora International.

Bulbs in the spotlight

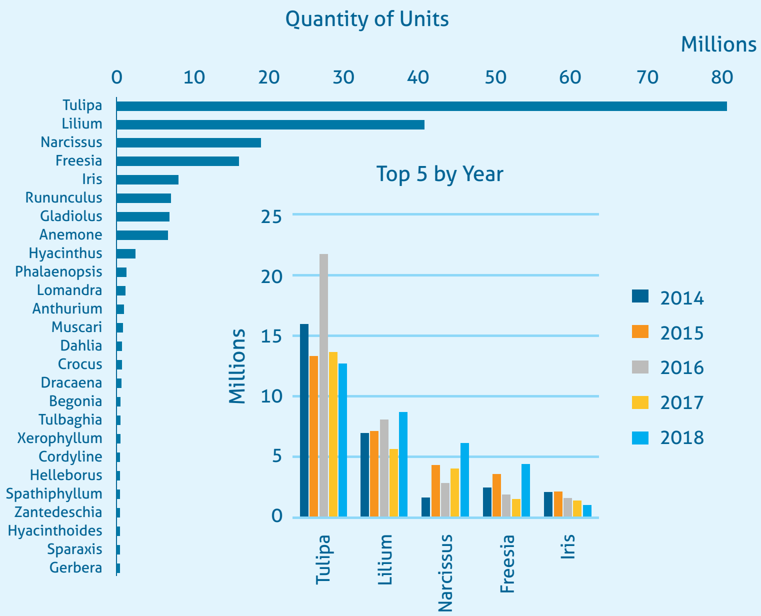
Of all the plants imported into New Zealand each year, bulbs are the largest import by volume. Almost NZ $5 million (value for duty) bulbs are imported each year, with 93% of this trade coming from the Netherlands.

The Netherlands is the world's leading flower bulb producer, accounting for about 70% of the world flower bulb production and 90% of world trade.

Tulip bulbs top the charts, averaging around 16 million units per year, followed by 8 million lilies, 4 million daffodils (*Narcissus*), 3 million *Freesia* and 2 million Iris bulbs per year.

Most of the bulbs imported from the Netherlands are produced according to the Dutch Bulb Certification Scheme, BKD (Bloembollenkeuringsdienst / the Flower Bulb Inspection Service). The scheme rules include both quality and quarantine checks, with inspection during the growing season and at export.

Import volume by commodity – 2014-2019



To ensure tulip health, a flowering tulip crop is walked and inspected in April and May to remove not-true-to-type cultivars or virus-affected plants.

BKD Inspectors make a first visual assessment of quality aspects in the field, after which lots are granted class 1, class ST (standard) and class EGE (end-use Europe). Months later, before shipping bulbs to a non-European destination, bulbs are inspected again in the warehouses.

Only Class 1 bulbs meet New Zealand's phytosanitary requirements so that the BKD can issue a phytosanitary certificate.

New Zealand produces counter-season bulbs for the cut-flower market in the United States, Europe and Thailand.

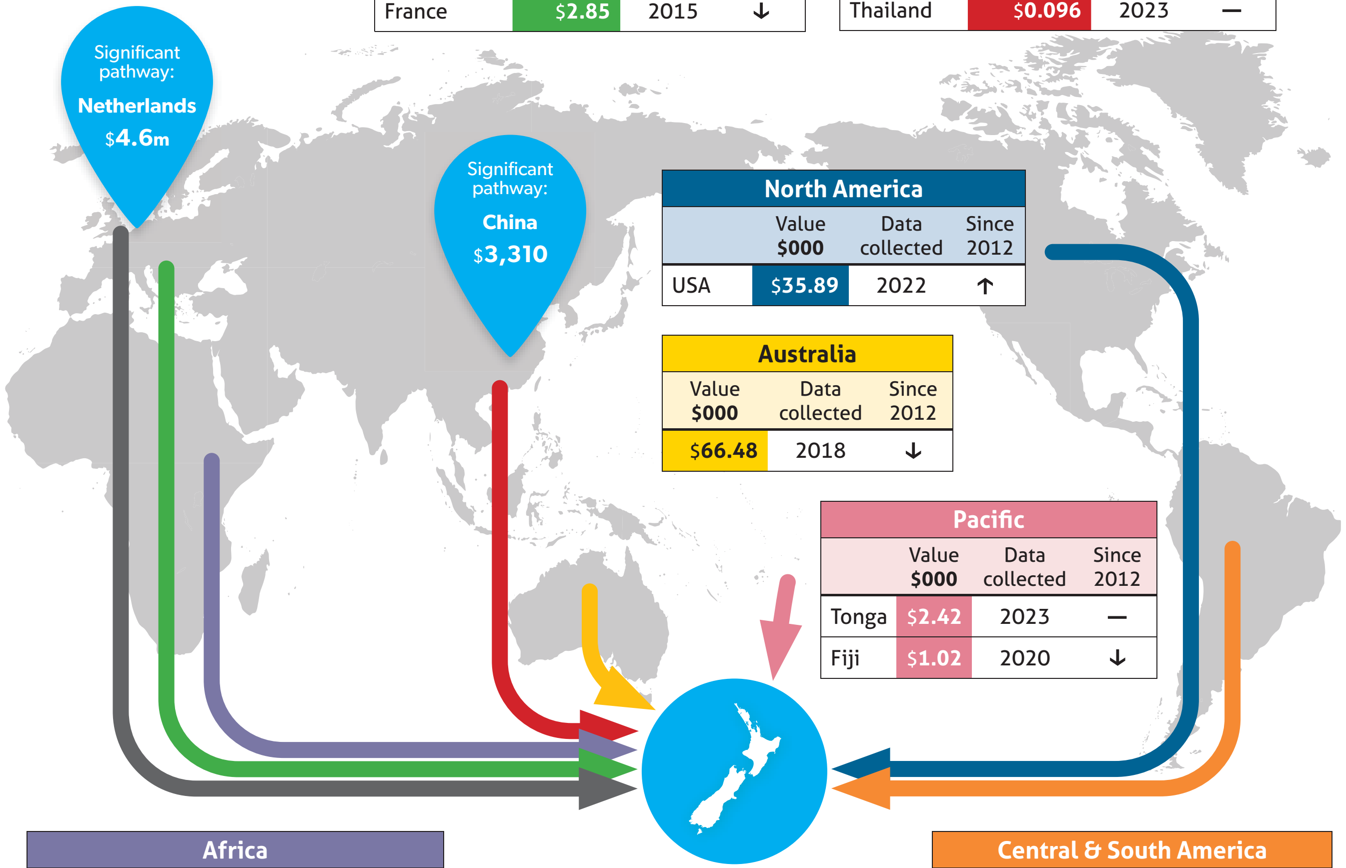
Value of bulb exports - Fresh Facts, 2023 **Fresh-Facts – December-2023.pdf** (unitedfresh.co.nz)	
Tulips	20.79 million, fob
Lilium	20.13 million, fob
Others	0.74 million, fob

Export sources: Bulbs, tubers and roots.

United Kingdom & Ireland		
Value **$000**	Data collected	Since 2012
$0.977	2019	—

Continental Europe	Value **$000**	Data collected	Since 2012
Netherlands	$4.6m	2023	↑
Belgium	$29.61	2010	↑
Italy	$15.49	2023	↓
France	$2.85	2015	↓

Asia	Value **$000**	Data collected	Since 2012
Malaysia	$70.00	2021	↓
India	$30.00	2017	—
Israel	$27.92	2023	↓
Indonesia	$11.18	2021	—
China	$3.31	2023	↑
Hong Kong	$2.44	2016	—
Thailand	$0.096	2023	—



North America	Value **$000**	Data collected	Since 2012
USA	$35.89	2022	↑

Australia		
Value **$000**	Data collected	Since 2012
$66.48	2018	↓

Pacific	Value **$000**	Data collected	Since 2012
Tonga	$2.42	2023	—
Fiji	$1.02	2020	↓

Africa	Value **$000**	Data collected	Since 2012
South Africa	$56.59	2023	↑

Central & South America	Value **$000**	Data collected	Since 2012
Colombia	$0.524	2019	—

New Zealand

Total import value:

$4,926,827

Key:
- ↑ slight increase
- ↑ significant increase
- ↓ slight decrease
- — no change

Data from Stats NZ. Note that the 2012 comparison data includes all live plants, bulbs, cut flowers and foliage together.

nzppi
NEW ZEALAND PLANT PRODUCERS INCORPORATED

Export sources: Live plants (whole plants, cuttings, tissue cultures) and mushroom spawn.

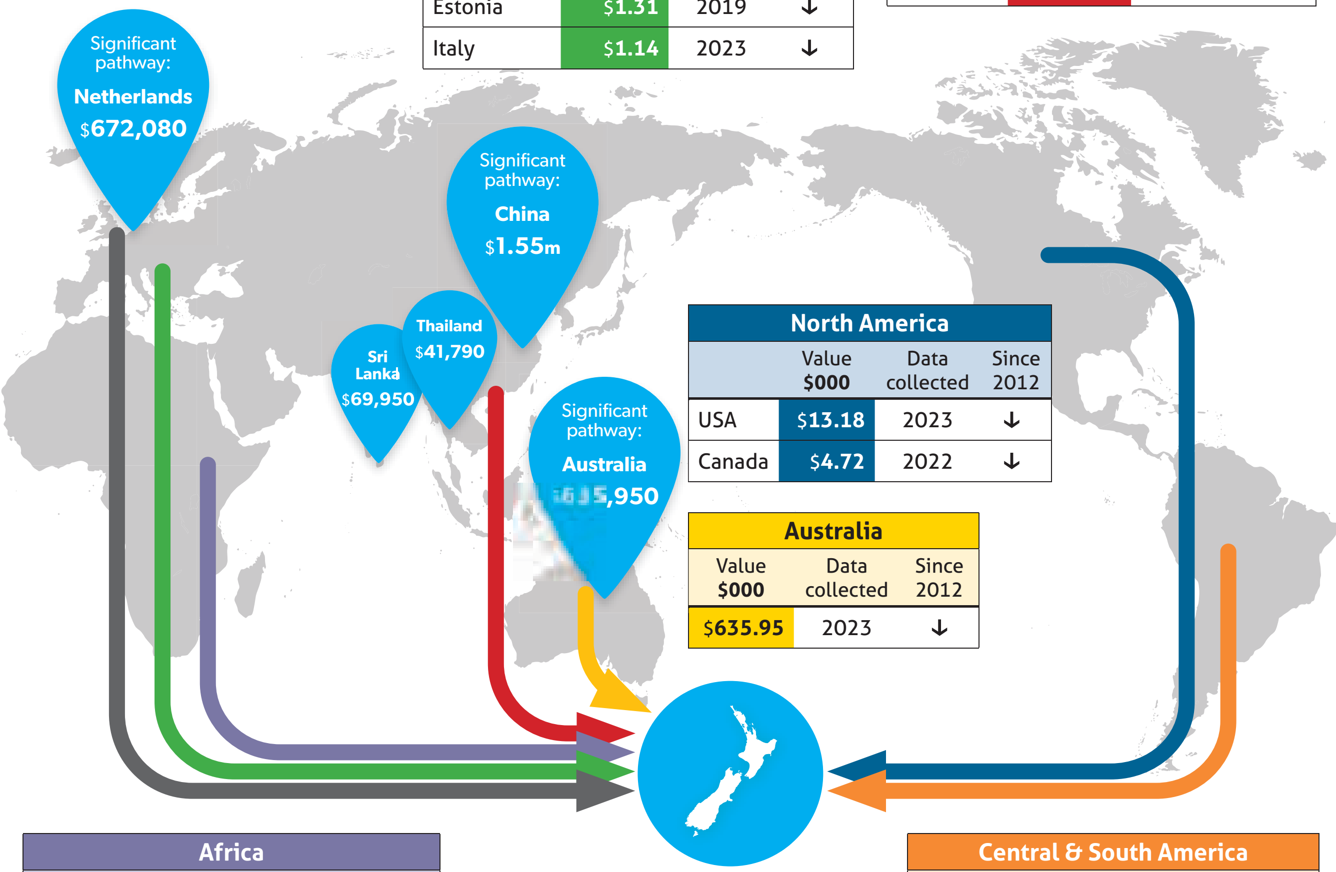
Asia

	Value $000	Data collected	Since 2012
China	$1.55m	2023	**↑**
India	$370.48	2023	—
Sri Lanka	$69.95	2023	**↑**
Thailand	$41.79	2023	—
Vietnam	$39.23	2023	**↑**
Japan	$12.84	2022	**↑**
Singapore	$9.58	2023	↓
Israel	$8.49	2023	↓
Indonesia	$6.98	2023	—
Malaysia	$6.18	2018	↓

	Value $000	Data collected	Since 2012
Netherlands	$672.08	2023	↑
Germany	$110.06	2023	**↑**
Belgium	$22.37	2017	**↑**
Poland	$16.82	2023	↑
Denmark	$10.06	2023	↑
Spain	$2.35	2023	↓
Estonia	$1.31	2019	↓
Italy	$1.14	2023	↓

United Kingdom & Ireland

	Value $000	Data collected	Since 2012
Ireland	$15.34	2015	↑
UK	$0.278	2019	—



North America

	Value $000	Data collected	Since 2012
USA	$13.18	2023	↓
Canada	$4.72	2022	↓

Australia

Value $000	Data collected	Since 2012
$635.95	2023	↓

Africa

	Value $000	Data collected	Since 2012
Togo	$20.24	2022	—
South Africa	$9.89	2023	↑
Zimbabwe	$2.07	2019	—
Uganda	$1.80	2017	—
Kenya	$1.02	2023	—

New Zealand

Total import value:

$3,887,514

Central & South America

	Value $000	Data collected	Since 2012
Ecuador	$426.00	2012	—
Costa Rica	$174.69	2023	↑
Guatemala	$48.58	2018	↑
Mexico	$3.48	2023	↑
Suriname	$2.85	2017	—
Brazil	$1.29	2013	—

Key:
- ↑ slight increase
- **↑** significant increase
- ↓ slight decrease
- — no change

Data from Stats NZ. Note that the 2012 comparison data includes all live plants, bulbs, cut flowers and foliage together.

Note due to the International tariff code, the Live plants data also includes mushroom spawn. The 2012 comparison data includes all live plants, mushroom spawn, bulbs, roots, cut flowers and foliage.

New tree genetics:
Superior selections for landscapes, streetscapes and gardens

The plant production industry takes a leading role in introducing new and better plants for our landscapes and future environments.

Internationally, efforts have been focused on breeding improved cultivars of tree species especially for urban and city environments. Many tree varieties planted decades ago have been superseded by newer cultivars, bred to fit into smaller spaces and coping better with urban conditions such as pollution, compacted soils, heat and drought. Traits such as pest and disease resistance, and reduction in weediness and litter potential are also being selected.

In New Zealand, several councils have developed urban afforestation plans to increase canopy cover to beat the heat and ameliorate some of the worst effects of climate change. There is a progressive move to increase biodiversity, increasing the use of native species in urban plantings, as well as ensuring diversity in exotic species to create resilience to future pest & disease incursions.

New Zealand is decades behind the rest of the world in importing and trialling new cultivars for these purposes. For example, seven cultivars of Canadian maples, *Acer rubrum*, are currently available

Table 1: A selection of Canadian maple cultivars (*Acer rubrum*).

Cultivars available in NZ	Year released	Cultivars not available in NZ	Year released	Improvement
Columnare	1942	New World	1998	tall weeping structure, excellent shade tree
Bowhall	1948	Red Rocket	1998	cold hardiness, seedless
Scanlon	1958	Frank Jr Redpointe	2006	greater heat and drought tolerance and pH adaptability
October Glory	1961	Katie Cole	2010	prolonged red colouration of new leaf growth
Fairview Flame	1964	Armstrong Gold	2013	improved columnar form, compact, brighter foliage colour
Red Sunset	1966	JSC Kingstwo	2015	drought and cold tolerance, variegated leaves
Brandywine	1994	Miller	2017	mildew-resistance, early autumn colour
		Red Sentinel	2024	anthracnose resistant, columnar, fiery red autumn colour

in New Zealand. See Table 1. The most recently imported cultivar is 'Brandywine' which was released in 1994 and was imported by Blue Mountain Nurseries in tissue culture. At least eight new improved cultivars have been released into the market since 1996 which have not been imported and are not available here.

Cultivars cannot be imported as seed and must be imported through quarantine as tissue culture, or cuttings or budwood for grafting.

Leanne Gillies from Flemings Nursery is excited about some of the newer tree cultivars bred by JF Schmit nursery in Oregon, USA which are being grown and trialled in Australia.

The Canadian maple cultivar 'October Glory' was considered the benchmark for autumn colour when it was released in 1961. The newer release 'Frank Jr. Redpointe' has the potential to supersede this. It was bred specifically for urban environments and has significantly improved pH adaptability, and better heat and drought tolerance than previous cultivars. It has a straight and dominate central leader, resulting in strong branch angles that make it more resilient to strong winds.

Newer selections of columnar oaks are also looking promising. Oaks are very resilient to heat, drought and storms, and new columnar hybrids are fit better in denser city environments than the wide canopy

Acer 'October Glory', the previous benchmark for autumn colour, released in 1961.

Acer 'Frank Jr. Redpoint', a recent cultivar bred for city environments.

species typically planted 100 years ago. *Quercus* 'American Dream' is still in the testing stage at Flemings Nurseries but has attracted lots of attention for its very good form, coppery red new spring growth and big glossy green leaves in summer. It's a hybrid between swamp white oak (Q. *bicolor*) and fastigiate European oak (Q. *robur fastigiata*). Also looking promising in trials is *Quercus bicolor* 'Beacon' and *Quercus* 'Crimson spire'.

As Australia is free from most of the pests and diseases of concern in the Northern Hemisphere, in future it may be possible to import these cultivars from Australia to reduce quarantine time and expenses here.

Leanne Gillies,
Research and Innovation Manager
Flemings Nursery, Australia.

A selection of new tree releases

Nyssa sylvatica 'David Odom'
Afterburner® Tupelo
IMPROVEMENT: Uniform branch structure and straight central leader.

Quercus bicolor 'JFS-KW12' PP 23632
American Dream® Oak
IMPROVEMENT: Anthracnose and powdery mildew resistance.

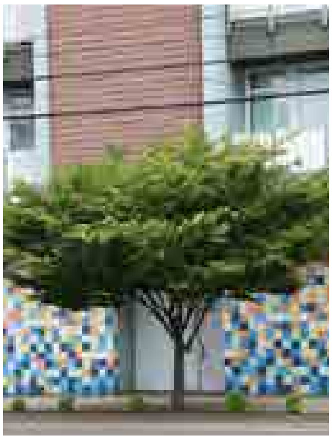
Carpinus caroliniana
American Hornbeam
IMPROVEMENT: Widely adaptable small tree.

Acer rubrum 'WW Warren'
Red Sentinel® Maple
IMPROVEMENT: Anthracnose resistant, columnar.

Acer saccharum 'Barrett Cole'
Apollo® Maple
IMPROVEMENT: Dwarf, columnar Sugar Maple, withstands heat.

Pyrus x triploida
Chastity® Pear
IMPROVEMENT: Sterile triploid pear, good for under powerlines.

Acer griseum Copper Rocket®
Paperbark Maple
IMPROVEMENT: Tailored for narrow spaces, satin smooth bark exfoliates in coppery curls.



Zelkova serrata 'Schmidtlow'
Wireless® Zelkova
IMPROVEMENT: Fits under powerlines.

Tilia cordata 'Corzam'
Corinthian® Linden
IMPROVEMENT: Narrowest of the Linden cultivars.

Acer platanoides
'Crimson Sentry'
Crimson Sentry Maple
IMPROVEMENT: Compact columnar, heavily branched upright tree.

Quercus x bimundorum
'Crimschmidt'
Crimson Spire™ Oak
IMPROVEMENT: Mildew resistant, columnar with red autumn colour.

Malus x adstringens 'Durleo'
Gladiator™ Crabapple
IMPROVEMENT: Dwarf, narrow, upright crabapple.

Bred by JF Schmidt in Oregon, USA.

Taming invasive species through plant breeding

Plant breeders are working to create sterile plant cultivars to replace weedier varieties, and these are progressively being released to the marketplace.

Interspecific hybridisation, polyploidy, and mutation breeding are the main breeding strategies being used to induce sterility or low seeding cultivars.

Hybridisation

Hybridisation involving wide crosses between two or more distantly related species (and even between genera) has been a successful strategy for developing sterile cultivars. Chromosome dissimilarities between the parental genomes can result in meiotic failure during gamete formation, leading to sterility.

Prunus 'Shimidsu Sakura' – a sterile Japanese cherry cutlivar, bred using complex interspecific hybridisation hundreds of years ago.

The double-flowered Japanese flowering cherries (*Prunus serrulata*) are thought to have been bred around the seventeenth century A.D., through a complex interspecific hybridization between Oshima cherry (*P. speciosa*) and wild species such as *P. sargentii, P. itosakura, P. leveilleana, P. apetala, P. incisa* and *P. campanulata*.

A floral study by NZPPI and Plant & Food Research in 2022 found the cultivars *Prunus* 'Kanzan' and *P.* 'Shimidsu Sakura' are completely sterile, with the ovary and styles replaced by leaflets in the flowers. A third cultivar, *Prunus* 'Kiku Shidare Sakura' was found to have low fertility. All three are exempt from the ban under the Auckland Regional Pest Management Plan 2020-2030.

In North Carolina, Dr Thomas Ranney from NC State University has successfully used wide interspecific hybridisation to develop sterile cultivars of Japanese barberries (*Berberis*) and privet (*Ligustrum*). Also from NC State University, Dr Dennis Werner has hybridized *Buddleia* 'Blue Chip' with other species like *B. globosa* and *B. lindleyana* to produce varieties that are significantly less fertile or completely sterile.

At the University of Connecticut, Dr Mark Brand has also bred sterile Japanese barberries (*Berberis*) and *Buddleia*, as well as chokeberries (*Aronia*) and cold-hardy rhododendrons and sand cherries. His ongoing breeding work now focuses on *Pieris, Clethra*, shrub dogwoods, yellow rhododendron, and native shrubs, all of which have potential as non-invasive, ornamental landscape plants.

Buddleia 'Blue chip', a low-fertility hybrid derived from crosses between *B. davidii, B. globosa,* and *B. lindleyana.* Dr Mark Brand.

Fountain grass (*Pennisetum alopecuroides*) are popular ornamental grasses overseas, but their extremely high seed viability can make them invasive in local ecosystems. The species is banned from import into New Zealand for this reason. Dr Wayne Hanna at the University of Georgia has developed a range of completely sterile trispecific hybrids, from complex crosses among *P. glaucum, P. purpureum,* and *P. squamulatum.* The cultivars are male and female sterile, drought tolerant, and represent a broad range of heights, texture, colour, and vigour. Some are also resistant to *Helminthosporium* leaf spot.

Pennisetum 'Princess Caroline' – one of a range of trispecific hybrids bred to be completely sterile. Photo: Dr Wayne Hanna.

Mutation breeding

Dr Hanna has also developed a range of low-seed *Pennisetum* cultivars using mutation breeding, irradiating seeds with Cobalt 60 gamma radiation. These cultivars have between 95 – 98% reduced seed set compared to their parent commercial cultivars.

Pennisetum 'Etoufee' – one of five low-seeding cultivars developed through seed irradiation. Photo: Dr. Wayne Hanna.

Agapanthus 'Blue Finn', producing zero% seed set in trials at the Auckland Botanic Garden, earning the trade mark Ecopanthus™. Photo: Kiwiflora International.

Sterility trials

No matter which breeding method has been used, putatively sterile or low-fertility cultivars need to be assessed to assure they meet requirements for exemption from local bans and can be sold. The cultivars are planted near pollinators and fertile control plants, and flowering, seed production and seed-set are monitored over several years in different environments. It is good practice to include various genotypes in the trial to allow for genetic crossbreeding and crossing with different ploidy levels.

Absolute sterility is the gold standard, but some local authorities also accept low-fertility or low-seeding cultivars that produce viable seed below a set threshold. For example, the Oregon Department of Agriculture in the USA sets a threshold of 2% (or less) viable seed for *Buddleia* genotypes to be approved for sale.

In New Zealand, a 2% threshold has been applied to the regulation of *Agapanthus*, which is a controlled plant under the Auckland Regional Pest Management Plan 2020-2030. A seed-set trial was established at the Auckland and Christchurch Botanic Gardens starting in 2012 to assess seed set of *Agapanthus* cultivars over several years. Cultivars were graded as 'no observed seed set, very low set, low set, medium set, high set, or very high set'. Cultivars that set abundant seed were progressively culled from the Auckland collection, except for some taller-growing 'wild-type' *Agapanthus praecox* subsp. *orientalis*, which were retained as pollinators.

Low-fertility cultivars produced less than 2% viable seeds compared to high-fertility cultivars evaluated under the same conditions and these selections are marketed under the Ecopanthus™ trademark and can be sold in Auckland.

A full list of low-fertility *Agapanthus* cultivars can be found on the Auckland Botanic Gardens website, Agapanthus for Auckland.

Triploid hybrids

Ploidy manipulation is a proven method for developing sterile triploids in plants, and has been used to develop seedless food crops such as bananas, watermelons, and some cultivars of grapes.

Ryan Contreras at Oregon State University has been pursuing polyploidy across a range of different plants to develop sterile or non-invasive cultivars.

Ploidy refers to the number of chromosome sets found in an organism. Most organisms have two sets (diploids = 2x) but plants are capable of existing with more than two sets of chromosomes. In nature, triploids can occur through production of unreduced (2n) gametes. However, plant breeders can double the chromosomes of a diploid plant using various chemicals and the resulting tetraploid (4x) plant is then crossed with the diploid plant to create triploids (3x).

Triploids are mostly sterile because plants with an odd ploidy number cannot be equally divided during meiosis such that daughter cells contain between n and 2n chromosomes. In most cases where rare seedlings do arise from triploids, they often are aneuploids with reduced fitness and pose little or no ecological threat to escape cultivation.

Maples are extremely adaptable and tolerant of air pollution, and there is a wide range of desirable cultivars with columnar growth habit, and improved autumn colours. However, many maples have the significant drawback of being weedy. Several species have escaped cultivation and become invasive to the point of being banned in some states, for example *Acer tataricum* ssp. *ginnala* (Amur maple) and *A. platanoides* (Norway maple).

Contreras and Hoskins have used the technique to develop triploid maples (Amur and Norway maples (*Acer tataricum* ssp. *ginnala* and *A. platanoides*, respectively). These maple species are banned in some states as they have escaped cultivation and become invasive. However, they are useful street and shade trees in the urban landscape because of their adaptability and tolerance to air pollution, and a wide range of cultivars have a columnar growth habit and improved autumn colours. Evaluation of these triploids is ongoing, but those that have flowered – Amur maples only to date – have yielded no viable seedlings.

Triploid Amur and Norway maple after one growing season. Photo: Ryan Contreras

While commercial propagation usually involves chip budding the desired cultivar onto seedling rootstock, the potential for graft failure or outgrowth of rootstock has led to the production of these triploid maples in tissue culture. What is encouraging is both species are amenable to this method of propagation and grow on well in production after acclimation.

Other crops being developed include sterile *Berberis thunbergii, Hibiscus syriacus, Buddleia, Prunus laurocerasus* and *Spiraea*.

Ryan Contreras,
Professor and Associate Head Department of Horticulture, Oregon State University

Plant hybridisation and HSNO

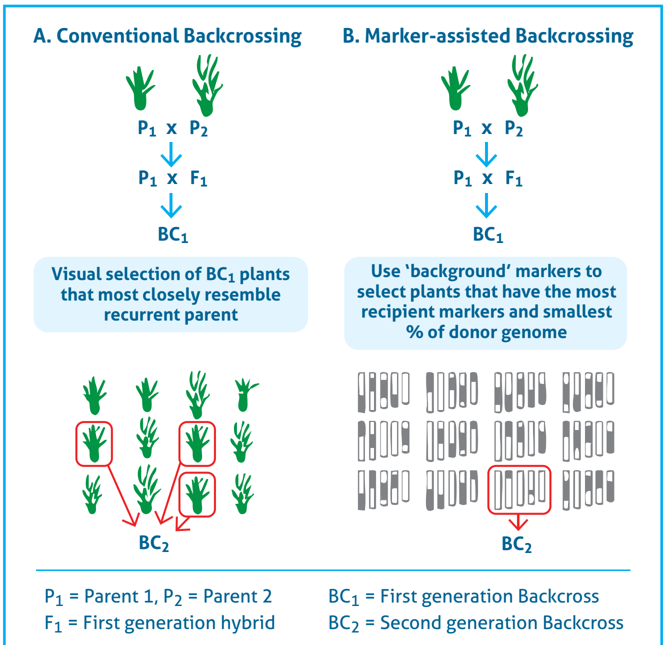
Plant improvement relies heavily on access to novel genetics and beneficial traits.

For many cultivated plants with narrow gene pools, wild relatives are an important source of genetic variability. By crossing cultivated plants with their wild relatives, breeders can introduce genes that confer resistance to pests and diseases, as well as traits that improve productivity, quality, and environmental adaptability. This hybridisation process is a cornerstone of modern plant breeding, but it also intersects with regulatory frameworks such as New Zealand's Hazardous Substances and New Organisms Act (HSNO).

In New Zealand, the introduction of hybrids involving a parent species not listed on the Ministry for Primary Industries' (MPI) Plants Biosecurity Index (PBI) requires approval from the Environmental Protection Authority (EPA). Both the blight-resistant *Buxus* and *Xylella*-resistant grapevines featured in this issue are current examples.

A closer look at crop breeding history reveals an interesting contradiction. Many widely used crop cultivars likely involve species not listed on the PBI. For instance, over half of modern potato varieties incorporate genes from *Solanum demissum*, a wild species that provides resistance to *Phytophthora infestans*, the pathogen responsible for late blight. Similarly, almost all modern tomato cultivars contain disease-resistance genes from wild relatives such as *Lycopersicum peruvianum* and *L. cheesemanii*, none of which appear on the PBI. These examples demonstrate that some of the most important advances in crop improvement have relied on genetic resources that would face regulatory hurdles today.

First-generation hybrids (F1) typically include both desirable and undesirable traits from their wild parent. Breeders use a technique called backcrossing to refine these hybrids, repeatedly crossing them with the cultivated parent while selecting for specific beneficial traits. By the third backcross generation (BC3), the hybrid is genetically over 93% similar to the recurrent parent, except for the targeted trait(s). This process helps create improved cultivars that retain the desirable qualities of the commercial parent while incorporating valuable traits from the wild donor.



Conventional (A) versus marker-assisted (B) backcrossing.

Modern breeding tools, such as marker-assisted selection (MAS) and molecular markers, have further streamlined this process. These technologies allow breeders to track beneficial traits at the DNA level, reducing the amount of unwanted genetic material and accelerate the development of improved varieties.

Given these advancements, it may be time to revisit the regulatory concept of a "hybrid species." Back in 2008, scientists and regulators explored whether hybrids with less than one-sixteenth of the donor species' genetic material (equivalent to BC3) should be considered equivalent to the recurrent species for regulatory purposes. Revisiting this concept could provide a more targeted approach, balancing environmental concerns with the need to encourage innovation in our plant production sectors.

Kathryn Hurr, NZPPI.

CRISPR-Cas and new genetic technologies

In the last 10 years, new 'gene-editing' techniques have entered laboratories around the world which have the potential to revolutionise plant science.

Most of the gene editing techniques use an enzyme-RNA complex called CRISPR-Cas. This complex, when it is introduced into a cell, can make precise cuts and repairs to parts of an organism's DNA code. Although other systems have been developed which can also "edit" the code, CRISPR-Cas is by far the most-commonly used by biologists, both in medicine and in plant/animal biology.

CRISPR stands for "clustered regularly interspaced short palindromic repeats". These are pieces of RNA, which load into the protein part of the complex called a Cas-nuclease. Scientists first discovered this naturally occurring enzyme complex in bacteria, where it has a role in defending the cell from viruses.

The technology requires sophisticated labs and expertise in tissue culture, making it inaccessible for casual or unregulated use. The process involves introducing the CRISPR-Cas complex into cells, where it uses a custom RNA guide to locate a specific matching DNA sequence and make a precise cut. The cell then naturally repairs the cut, resulting in genetic variations similar to those that very frequently occur naturally.

Gene editing is different from GMOs (genetically modified organisms). Since the 1990's GMOs have been developed and deployed in both medicine and agriculture. GMO plants have now become around 18% of agricultural value. GMOs are organisms with added DNA (often from the same plants DNA code, but new never-the-less).

With CRISPR-Cas edited organisms, the plant or animal has no new DNA (no new genetic material). In fact, DNA changes induced by CRISPR-Cas are a lot less than changes induced by breeding.

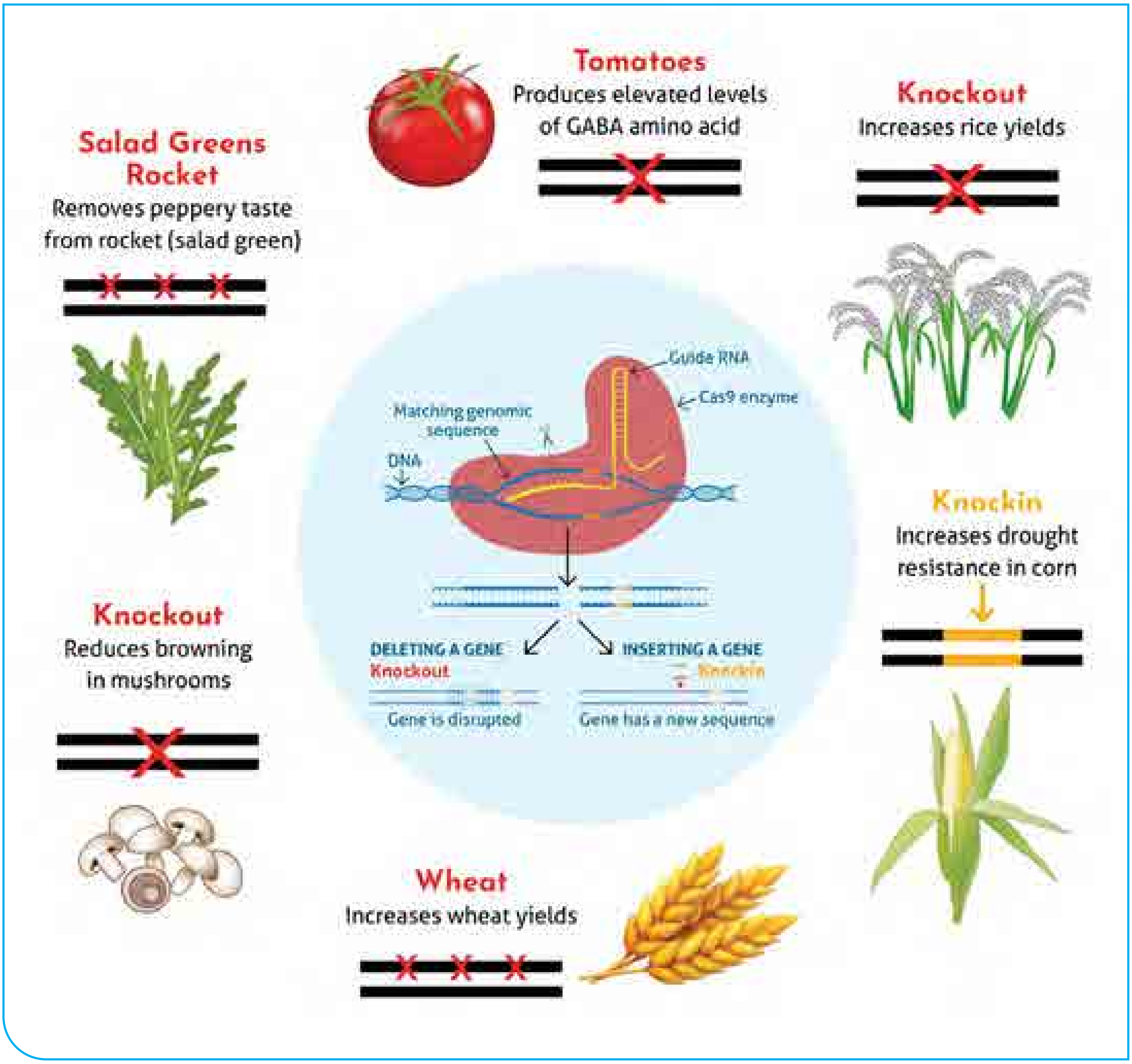
> Gene editing is just one tool in the plant production sector, and our sectors need as many tools as possible in the face of a changing climate and very competitive international markets.

In all countries who have considered how to regulate gene edited organisms, the decision has been made to regulate GMOs and not regulate gene edited plants if the organism has no new DNA. Some counties are still pondering this decision regulation-wise, including New Zealand and the European Union.

A few new crop plant cultivars which have genetic variants of genes generated by CRISPR-Cas are now being grown and sold in countries such as Japan and the USA.

Some examples include:

- higher-yielding wheat, made by editing three genes (an American study), set to be trialled in 45 sites in Australia in 2025.
- tomatoes (in Japanese markets) enriched with gamma-aminobutyric acid (GABA), an amino acid which is naturally in tomato but is elevated by an edit. This compound aids relaxation and helps lower blood pressure.
- The salad green, rocket (arugula) with no "peppery taste" (an American product) produced by edits that reduce this set of compounds.



GMOs have faced resistance in New Zealand, particularly in agriculture, however gene editing could offer a less controversial alternative. New Zealand's current regulations classify gene-edited organisms as GMOs, effectively barring their use. This is not the case in most countries around the world.

The regulatory settings in NZ are under review and may enable trials of such crops in the future. The impacts of this need to be thought through and managed. Gene editing is just one tool in the plant production sector, and our sectors need as many tools as possible in the face of a changing climate and very competitive international markets. With appropriate regulation and industry support, CRISPR-Cas could provide vital tools to enhance crop resilience and maintain New Zealand's agricultural edge in a changing world.

Professor Andrew Allen,
Plant & Food Research.

Reducing quarantine time with accelerated aging

Most tree crop species require a stringent two-year post-entry quarantine (PEQ) process in Level 3B. Researchers are exploring ways to accelerate this process without compromising detection accuracy.

Above: Cherry plants growing on AA room.

The team, L to R: Sandra Visnovsky, Dr Virginia Marroni, Dr Pieter-Willem Hendriks, Ping Koay, Mary Horner and Associate Professor Dr Clive Kaiser.

One promising approach is "Speed Breeding" which has been used to halve the time to maturity in annual crops like wheat and barley by using extended daylight conditions of 22–24 hours. This technique relies on low-cost LEDs to promote faster growth and reproduction.

Professor Derrick Moot at Lincoln University started a project on Speed Breeding in 2019 on kiwifruit. This work was adapted by Associate Professor Dr. Clive Kaiser (Lincoln University) to look at cherry trees, collaborating with Plant & Food Research scientists and Ministry for Primary Industries (MPI) personnel on a Better Border Biosecurity (B3) project titled "Accelerated Aging of Plants for Post-Entry Quarantine Testing Period."

The project compares current MPI PEQ protocols with an accelerated aging protocol using climate-controlled Biotron facilities at Lincoln University. Researchers are monitoring cherry trees' growth and their ability to detect three target pathogens: *Prunus necrotic ringspot virus, Pseudomonas syringae pv. syringae,* and *Monilinia fructicola.* These pathogens are present in New Zealand, and closely related to MPI-listed quarantine pathogens, providing valuable insights into the feasibility for PEQ.

Dr. Kaiser's previous work at the Norwegian Agricultural Research Institute informed the study. Norway's short growing season of four months required techniques to simulate rapid growth cycles. To replicate winter dormancy, plant material is held at 5°C for 50 days before transitioning to simulated spring conditions. Early results show successful "spring" detection of *Prunus necrotic ringspot virus* under accelerated aging conditions. Disease symptoms appear more pronounced under these conditions, though further verification is needed.

If successful, this innovative protocol could nearly halve the time required for growth in PEQ while maintaining rigorous detection standards. This would significantly enhance New Zealand's ability to import and propagate new plant genetics, supporting the country's agricultural development amidst growing global trade demands and climate challenges.

Clive Kaiser (Lincoln University), Mary Horner and Virginia Marroni (Plant & Food Research).

High-throughput sequencing for screening plant imports

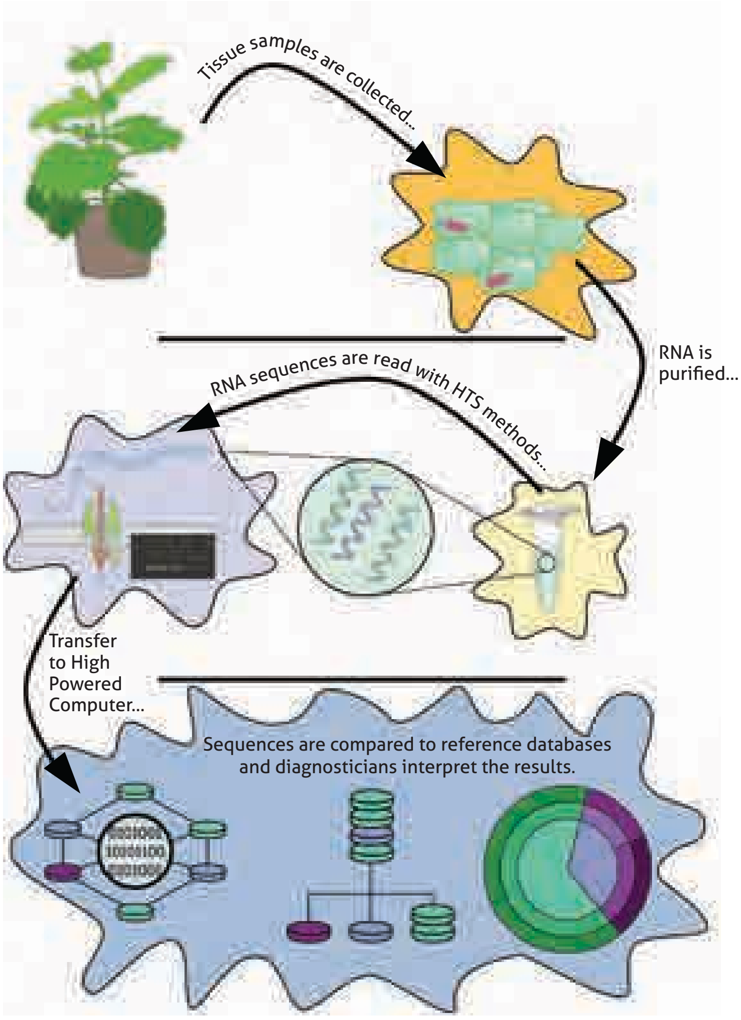
There are many high-throughput sequencing (HTS) technologies available, and all can capture massive amounts of genomic sequence data from any biological sample.

The application of HTS to biosecurity and phytosanitary health is a rapidly developing field across the world. HTS offers advantages over conventional tests, such as PCR and ELISA, which are tailored to a single pathogen or group of related pathogens. HTS detects both known, new and emerging pathogens and is particularly useful for new host detections.

Scientists at the Plant Health and Environmental Laboratory (PHEL) have been using HTS for symptomatic surveillance samples for several years using Oxford Nanopore Technologies (ONT) MinION. In 2024, after a period of optimization, PHEL began using Illumina NovaSeq for asymptomatic plant import testing of strawberry, grapevine, and *Prunus* germplasm.

The Illumina NovaSeq platform uses sequencing by synthesis chemistry to analyse nucleic acid (RNA/DNA) base-by-base. Whereas ONT uses a protein motor to thread the nucleic acid through a pore which reads each base as it passes through. RNA sequencing gives a snapshot of all the active biological processes happening inside a plant, making it ideal for detecting live, active infections and monitoring real-time biological processes.

The HTS workflow starts in the laboratory with the extraction and purification of nucleic acid from plant tissues and finishes with high-performance computing (HPC) comparing the RNA sequence data obtained against reference databases to determine if they match known sequences. The method makes it possible to pinpoint whether any harmful viruses are present, including those that may not have been seen before.



High throughput sequencing method.
Credit: Dave Waite, Bioinformatician at PHEL.

A new improved HTS method for virus detection is in the works, called tiled-amplicon PCR. This works by targeting specific pieces of viral genetic material. PHEL researchers have tested it on strawberry samples by adding different amounts of virus to see how sensitive and accurate the method is at picking up even tiny traces of infection.

Dave Waite (Bioinformatician) and Jeremy Thompson (Team Manager Virology) at PHEL
Ministry for Primary Industries

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