A regular feature to inform industry about research projects being undertaken for their benefit. Newly approved projects (when available) are briefly summarised and longer reports will describe what has been achieved so far. When completed, each project will be reported in full detail with references on nzwine.com

Falcon Ridge Estate. Chocolate Dog Studio

Research Supplement

Information and updates on Bragato Research Institute research programmes

CONTRACTED RESEARCH PROJECTS

Quality Wine Styles for Existing and Developing Markets

Breaking the quality-productivity seesaw in wine grape production (Pinot Noir Programme)
University of Auckland, Plant & Food Research and Lincoln University (Various) jointly funded by NZW and MBIE

Prevention of quercetin instability in bottled wine
Indevin Group (G Flego)

The effect of winemaking decisions on polysaccharide content in wine
University of Auckland (B Fedrizzi)

The importance of green: understanding 'green' and 'herbaceous' characters in Pinot noir wine and their role in driving judgements of perceived quality.
Lincoln University (D Torrico)

Exploring reductive aromas in Pinot noir
University of Auckland (B Fedrizzi)

Precipitation of calcium tartrate and other compounds in wine
University of Canterbury (K Morison)

Potential applications of nanotechnology for wine growing in New Zealand
University of Auckland (M Kah)

National Vine Collection Virus Eradication
Bragato Research Institute (D Lizamore)

Pests and Disease

Improving remedial surgery practices for control of grapevine trunk disease to increase vineyard longevity
Linnaeus (E van Zijll de Jong), South Australian Research & Development Institute (M Sosnowski)

Weevils in New Zealand vineyards
Bragato Research Institute (P Epee)

Cost Reduction/Increased Profitability

Long spur pruning as an alternative to cane pruning for Sauvignon blanc in Marlborough
Bragato Research Institute (C Vasconcelos)

The Vineyard Environment

Vineyard Ecosystems Programme
University of Auckland and Plant & Food Research (Various) Jointly funded by NZW and MBIE.

Microbial Responses to Under Vine Treatment
Bragato Research Institute (M Barry)

Shared Vision for Land Use in Marlborough
Bragato Research Institute (M Barry)

Regenerating Vineyard Soils - Phase One
Bragato Research Institute (M Barry)

Development of an anaerobic chain-elongation bioprocess for grape marc valorisation
University of Auckland (S Yi)

Evaluating ecologically sustainable ways to disrupt the wine wētā-vine association
Plant & Food Research (J Vereijssen)

Weather and Climate

Sauvignon Blanc Grapevine Improvement Programme
Bragato Research Institute (D Lizamore)

Microbial community and vine responses to increasing temperatures in the New Zealand context
University of Auckland (S Knight)

Evaluating water use efficiency and drought tolerance of various rootstocks grafted to Sauvignon blanc
Bragato Research Institute (C Vasconcelos)

Tuned Vines
Bragato Research Institute (D Lizamore)

Ground wētā in the Awatere

Jessica Vereijssen, Mette Nielsen, Roger Wallis, Vaughn Bell, Richard Hunter, Stewart Graham (Plant & Food Research), Mary Morgan-Richards, and Steve Trewick (Massey University)

The endemic ground wētā, Hemiandrus bilobatus, lives in burrows in the soil, but its presence can negatively affect wine grape production. This is especially so in vineyards in the Awatere region in Marlborough. Vine growth in early spring provides the ground wētā with a buffet of fresh buds to feed upon, which causes damage detrimental to vine growth and fruit yield.

The current ground wētā management tool sees plastic sleeves wrapped around vine trunks in an attempt to prevent wētā from accessing the cordon. However, the sleeves are costly to install and maintain, resulting in a significant waste-management issue. This new project, which started on 1 July 2022, is funded by New Zealand Winegrower (NZW) levies and brings together scientists from Plant & Food Research (PFR) and Massey University. PFR scientist Dr Jessica Vereijssen leads the project, which includes Professors Mary Morgan-Richards and Steve Trewick, both of Massey University in Palmerston North. Their knowledge and experience of wētā will be invaluable in helping this study achieve the goals of seeking to understand the wētā–vine association and develop environmentally sustainable solutions where vineyards and the ground wētā can co-exist.

The wider project team includes grower representatives from local wineries to ensure that any proposed solutions are practical and financially sustainable. Since the first wētā article was reported in this magazine in June/July 2022 (Wētā Work, page 40), good progress has been made. In early September 2022, PFR led a grower meeting at the Yealands Awatere Memorial Hall, which more than 20 growers and other interested parties attended. As well as describing the work to be done and potential solutions in future, PFR and growers identified 25 potential trial sites for wētā fieldwork.

Ground wētā during an evening survey in the Awatere winegrowing region in September 2022

Also in September, PFR and Massey University researchers visited the Awatere region to begin fieldwork in time for budburst. Training in daytime identification of wētā burrows was undertaken, which is not straightforward because the wētā make soil plugs or doors to

Evening surveys for the ground weta in the Awatere winegrowing region in September 2022

"These conversations will offer new insights into factors like wētā distribution, the extent of vine damage, and how it varies throughout the Awatere winegrowing region."

close their burrow entrances, so they are hidden from view. There are also other burrowing insects in the soil between the vines, such as Tasmanian pasture cockchafer and pasture wireworm, whose burrows need to be distinguished from the wētā burrows. Researchers collected several wētā, and tikanga Māori protocols were adhered to. These wētā are now at Massey University and PFR Motueka, where rearing and assessments of diet are underway. In addition to the ground wētā, several other commonly found insects were collected from various study sites to gauge their potential contribution to bud damage on vines.

PFR researchers again visited the Awatere region in September, where they visited 16 study vineyards, of which nine were visited at night. These included Māori-owned, conventional, and organic vineyards. Ground wētā were observed at several sites, with further field assessments undertaken again in mid-October for the later budburst varieties. The team will return in January 2023 for surveys to aid in understanding ground wētā behaviour and diet outside the budburst period. The information from the two periods will be used to formulate sustainable solutions for the future.

To round off this calendar year, the PFR team are looking to speak with up to 20 growers, who will be asked about their vineyards and experiences of wētā, how it has influenced different areas of their vineyards, and what practices or tactics have been adopted (or might be in future) to counter wētā damage. These conversations will offer new insights into factors like wētā distribution, the extent of vine damage, and how it varies throughout the Awatere winegrowing region. Analysis of the conversations with growers, coupled with field observations during budburst and in January, will be used to find solutions for ground wētā and commercial vineyards to co-exist in the Awatere region. In 2023, a PhD student, guided and supported by the Massey professors, is expected to join the research project.

ABOUT THE PROJECT

This three-year project is funded through the New Zealand Wine Futures Fund, which BRI launched in 2021 to bring new and novel ideas to levy-funded research. It is funded through NZW levies and project-managed by BRI. The wētā project has co-funding from Indevin, Pernod-Ricard, Yealands, and Hortus to support the Massey University PhD student. The science team is led by PFR, with significant in-kind contributions from Massey University.

Installing pitfall traps in a vineyard to catch walking/jumping insect.

SAUVIGNON BLANC GRAPEVINE IMPROVEMENT PROGRAMME

Resilience through diversity

Darrell Lizamore

This November marks the first year of the Sauvignon Blanc Grapevine Improvement Programme, also known as Sauvignon Blanc 2.0. In 2022, New Zealand's wine exports reached a new record of over $2 billion. Despite a challenging season that saw a 4% decrease in volume, export revenues continue to grow thanks to a 6% increase in value per litre. This growth is driven largely by a strong and steady global demand for New Zealand's iconic style of Sauvignon Blanc (Figure 1).
This success also reminds us of the unique position that New Zealand finds itself in as a wine-producing nation.

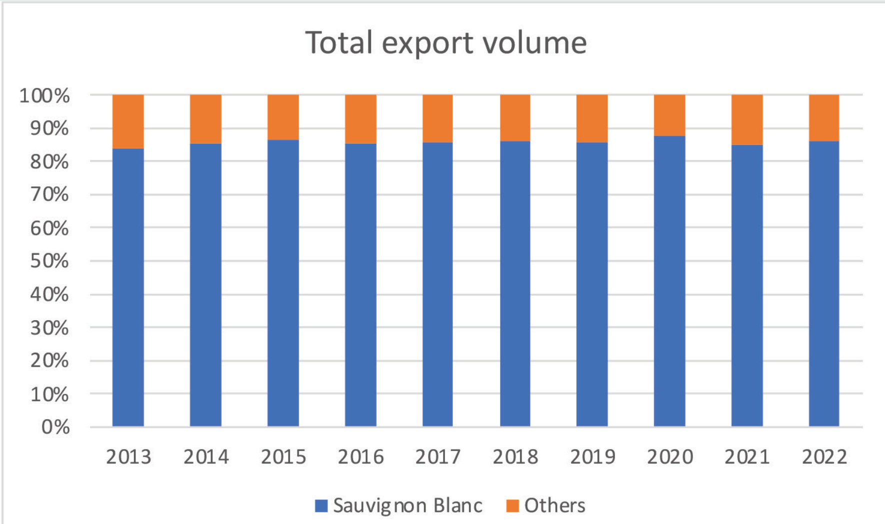

Figure 1: Sauvignon Blanc consistently makes up approximately 85% of export volume.

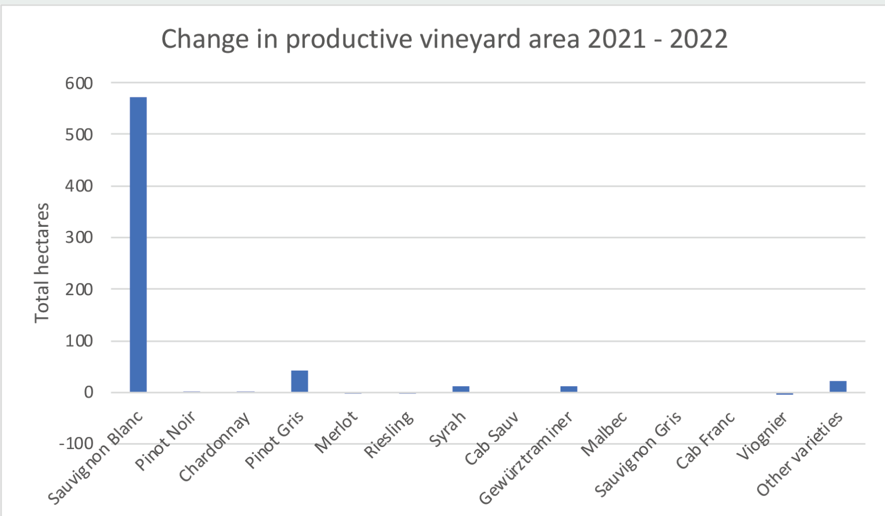

Figure 2: New Sauvignon Blanc planting continues to outpace all other varieties.

Multiple external audits of the wine sector have identified a lack of genetic diversity as the number one risk facing our industry. Although a more diversified portfolio of varieties remains a worthy goal for the industry, the reality of market demand for Sauvignon Blanc can't be ignored. Nor is it: the productive area of Sauvignon Blanc grew by 571 hectares in 2022.

The second greatest expansion was Pinot Gris which grew by only 43ha (Figure 2). Adding to the problem of varietal homogeneity is the over-reliance on a single genetic lineage. What we call 'Mass Select' in New Zealand originates from just a couple of plants of the same clone, UCD1 (also known as FPS1; see Nick Hoskins' excellent presentation from the 2019 NZSVO Sauvignon Blanc Workshop). Furthermore, in recent years rootstock 3301 has become something of a default choice for new vine orders (discussed below).

A LOCAL SOLUTION

Anyone who has visited a supermarket in the last decade will be familiar with the gains delivered by crop breeding efforts. Consumers can choose between many varieties of tomatoes, apples and even kiwifruit bred for their flavour, appearance, and longevity. Interestingly, most wine grape varieties were bred centuries ago and so have not benefited from any advances in crop domestication since then.

Sauvignon Blanc has been continuously propagated since at least the 17th century. In contrast with other major wine-producing nations, New Zealand has never had a significant grapevine breeding effort or clone collection programme. This leaves us with a desperate lack of material from which to begin, a problem that is exacerbated by slow and expensive import regulations. By definition, traditional breeding results in novel varieties, which creates a marketing challenge for winemakers. Plants produced using new techniques that generate targeted genetic changes would still be Sauvignon Blanc but are currently labelled and regulated as genetically

Figure 3. Bud sports spontaneously occur in vineyards but are usually lost at pruning.

modified organisms (GMOs) by New Zealand legislation. That's true even in the case where no foreign DNA is introduced, unlike in most countries, including Australia. In working with the industry to plan a new grapevine improvement programme, New Zealand Winegrowers (NZW), Bragato Research Institute (BRI) and research partners settled on an approach that takes advantage of a natural source of intravarietal diversity.

When plants are exposed to certain environmental stresses, they begin to adapt by relaxing their genetic uniformity. This occasionally leads to interesting new traits, which are the source of all diversity among clones of the same variety.

The lack of anthocyanin in white grape varieties is a classic example of this (Figure 3), and many who have spent enough time in the vineyard will have noticed plants that appear slightly different to their identical siblings. It may be a change in berry colour, bunch shape, timing of bud burst, or any other trait. These 'bud sports' are evidence of the spontaneous genetic changes that underlie natural evolution. This same approach can be used efficiently in a controlled environment. By exposing Sauvignon Blanc cells to carefully calibrated stress treatments, and then growing these into new vines, a collection of new vines is produced. Combined with an effort by industry partners to identify and collect bud sports in commercial vineyards, this represents a way to produce a local population of new Sauvignon Blanc diversity. Since the changes are not targeted, what remains is to screen the new vines for those that might be better in some way than the UCD1 starting material.

THE SAUVIGNON BLANC 2.0 PROGRAMME BEGINS

In 2021 a group of New Zealand wine industry members and grapevine researchers presented a business case to the Ministry for Primary Industry's (MPI) Industry Advisory Panel. We explained the scope of the challenges facing our industry and requested the government's co-investment to develop a collection of new Sauvignon Blanc vines. In November 2021, Agriculture Minister Damien O'Connor announced the start of a 7-year programme supported by MPI's Sustainable Food and Fibre Futures fund that would become the wine industry's largest research project to date.

Over the past year a governance group representing NZW and MPIs stakeholders has been set up, an international group of technical advisors identified, and a Commercial Advisory Group nominated from among the 23 grantor companies. Contracts have been signed with research partners Plant & Food Research (PFR) and Lincoln University to produce diverse new vines and then begin screening these for promising new traits (Figure 4). During the first twelve months of the programme, about 2,800 new vines have already been produced and are now maturing in growth chambers, mist tents and greenhouses (Figure 5).

Figure 4. The Grapes Research Team at PFR Lincoln, together with Sauvignon Blanc plantlets at varying levels of development. From left: Beatrice Fulton, Dr Philippa Barrell, Dr Mei Meiyalaghan, Dr Ross Bicknell, Michelle Thompson, and Lei Wang.

CUTTING-EDGE TECHNOLOGY

The process of breeding a new grape variety typically takes around 25 to30 years. Most of that time is spent growing up large numbers of plants to maturity before the first assessments of any new traits can be made. However, the rapid pace of research in plant genetics means that many genes that control traits such as drought and frost resilience, susceptibility to mildews and production of flavour and aroma compounds are now known. What's more, improvements in DNA sequencing technology make it feasible to identify changes in these genes long before the traits appear.

To enable promising new vines to be identified from among the large population within the term of the programme, BRI has recently installed a new DNA sequencer from Oxford Nanopore in the United Kingdom (Figure 6). The first of its kind in New Zealand, this sequencer is specifically suited to identifying the types of genetic changes that plants undergo in response to stress, at the scale that the programme requires. The goal is to detect differences in the genetics of the new vines earlier in their development, in much the way that new strains of Covid-19 could be tracked almost in real time. The past year has also been an exciting time of growth for BRI. To deliver the project, a group of researchers has been recruited to join BRI's Lincoln-based team (Figure 7). These scientists are bringing together their motivation and expertise in plant cell culture, trait selection, and genetic data analysis to establish a bespoke Grapevine Improvement programme with our industry.

A MORE SUBTLE APPROACH TO ROOTSTOCK SELECTION

Most new Sauvignon Blanc vines are grafted onto rootstock 3309, which although poorly suited to swampy soils grafts well, is generally versatile, and helps reduce the vigour that typifies this variety. However, 3309 is characteristically early ripening, promotes earlier bud burst than some alternative rootstocks, and has poor drought resistance. These traits may make 3309 less than ideal for some vineyards in future years.

Figure 5. Young Sauvignon Blanc plantlets growing under controlled conditions.

Early bud burst provides an increased risk of exposure to late spring frosts and water usage is a major concern for growers with a long-term outlook. Furthermore, the balanced acidity of many local Sauvignon Blanc wines is supported by our cool maritime environment. Trends towards warmer climactic conditions are leading many growers to consider what measures can be taken to delay ripening while acids and secondary metabolites such as thiols accumulate.

To collect robust statistical data about the effect of rootstock selection on Sauvignon Blanc, in October BRI planted a rootstock trial of 1,000 vines representing 15 different rootstock varieties. The vines and planting area have been contributed as in-kind funding by two of the programme's Gold grantors, The New Zealand Viticultural Nursery Association and Cloudy Bay. By using a randomised block design with three distinct irrigation zones, the trial is specifically set up to enable researchers to collect robust statistical information about vine establishment, water use efficiency and drought resilience in a place that exemplifies much of Marlborough's terroir.

A COLLECTION FOR THE FUTURE

New Zealand's wine industry undoubtedly faces challenges and opportunities in the coming years. The one thing we know for sure is that the future is uncertain. Market demand could continue to drive up prices for New Zealand's premium variety, but similarly, our industry may be forced to adapt to crises that could be slow or sudden. Some, like a warming climate, could be likened to the proverbial frog sitting in a pot of warming water. Others might be far more rapid.

In November 2010 the bacterial disease Pseudomonas syringae pv. Actinidiae (Psa) was detected in a Te Puke kiwifruit orchard. Less than two years later resistant material called Gold3 was identified in a large

Figure 6. A new high-throughput DNA sequencer has recently been installed at BRI's Grapevine Improvement lab in Lincoln.

collection of genetic diversity held by PFR and fast-tracked for release to growers. Despite the eventual replacement of the complete national gold kiwifruit crop at an estimated $800 million cost to the industry, kiwifruit now leads New Zealand's horticultural exports. Without a source of new material to hand, it has been estimated that a solution would have taken 7 to 10 years to develop.

On a positive note, vines with specifically selected traits might allow the expansion of the national vineyard into previously unsuitable land, reduce water and spray inputs, increase the productivity of current vineyards, deliver exciting new flavour profiles, or work synergistically with future management ideas, such as the new canopy programme currently being developed by BRI and its research partners.

A collection of clones displaying diverse traits within our premium national variety will put our wine industry in a much stronger position to adapt to changes and take advantage of new opportunities. And much of the knowledge gains about which genes and traits to select for, and how, will likely be transferrable to other varieties and even other crops.

Figure 7. BRI's growing Grapevine Improvement team working on Sauvignon Blanc improvement. From left: Dr Jessica Rivera-Perez, Ellie Bradley, Dr Bhanupratap Vanga, Dr Solomon Wante, and Dr Darrell Lizamore.

VINEYARD ECOSYSTEMS PROGRAMME

Management approach has a small but significant effect on vineyard soil biodiversity

Lucie Jiraska, Paulina Giraldo-Perez and Sarah Knight (School of Biological Sciences, University of Auckland); Beatrix Jones (School of Statistics, University of Auckland); Matthew Goddard (School of Life Sciences, University of Lincoln, UK)

Soils are more than dirt. Their fertility sustains terrestrial life, and this is driven by soil biology (the huge range of bacteria, fungi, and invertebrates). Soils grow 98% of all the food calories we eat and contain the largest levels of biodiversity on earth including, for example, useful bacteria that produce novel antibiotics. Soils contain more carbon than the atmosphere and plants combined. Losing soil health therefore means losing food and biodiversity and means the amount of carbon dioxide in the atmosphere will increase. We need to develop a robust understanding of the best ways to use and manage land to protect soils while still providing enough food, locking up atmospheric carbon and minimising biodiversity loss. However, we currently do not have sufficient scientific data to understand how to protect soils.

Here we describe part of the Vineyard Ecosystem (VE) programme, funded by the Ministry of Business, Innovation and Employment (MBIE) and New

> "Lastly, most studies on the effect of agrochemicals on biodiversity to date have not used DNA but have looked at one or a few key large species, like specific insects, and extrapolated the findings from these few species to all biodiversity."

Zealand Winegrowers (NZW), designed to provide data to help inform growers and landowners regarding decisions about how to manage their vineyards. Agricultural management approaches are now drawing more attention than ever before. The question of sustainability in agriculture and the growing pressure from consumers is influencing management decisions growers are facing every day. There is a strong belief that different agricultural management regimes have a significant impact on biodiversity. Until now, the evidence on the effect of management practices on soil biodiversity was scattered, at best, especially in vineyards. The VE programme has studied multiple vineyards over multiple seasons in New Zealand's two largest wine growing regions, Hawke's Bay and Marlborough stretched across North and South Island, to provide scientific evidence on the effects of agricultural management regimes on vineyard soil biodiversity. This will help guide evidence-based management decisions towards more sustainable practices.

Practically, there is a spectrum of management approaches within the programme rather than clear distinct categories. For the purposes of this research, we characterised the management regimes of the vineyards we sampled as either

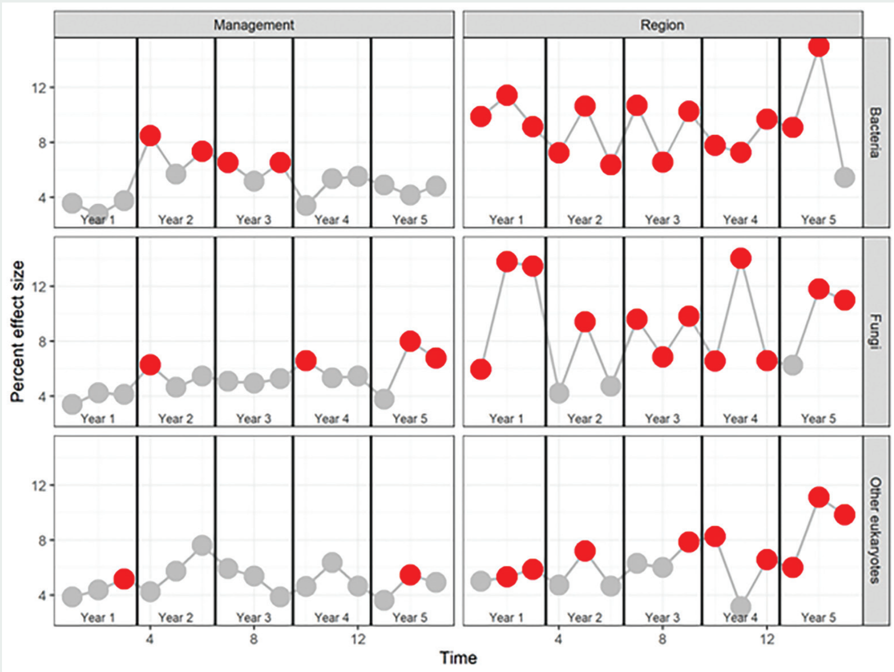

Figure 1: Diagram showing changes in percent effect size over time for each sampling time point for management and region for bacteria, fungi and other eukaryotes. Red dots represent sampling time points when the effect of management (left) or region (right) was statistically significant (P < 0.05). While the effect of region on biodiversity is consistently present, particularly for bacteria, the effect of management is not, and thus, it is likely context dependent.

'conventional' or 'conservation'. Conventional vineyards were not limited in their use of synthetic pesticides, while conservation vineyards did not use any synthetic herbicides to manage under vine ground cover, generally avoided synthetic fungicides, and on average applied four times less synthetic chemical applications than conventional vineyards according to spray diary data.

Classically, measuring biodiversity has relied on taxonomic experts counting large plants and animals that are visible to the naked eye. However, large plants and animals only represent a tiny fraction of overall biodiversity, and soil biodiversity is still poorly understood as most biodiversity is found as microscopic organisms, such as bacteria, fungi, and invertebrates.

Recently there has been a dramatic increase in accessibility to DNA sequencing technologies for monitoring biodiversity. By simply taking soil samples, we can extract DNA and estimate not only the total biodiversity in soils but also capture aspects of biodiversity from the surrounding ecosystem. Therefore, to investigate if there are differences in soil biodiversity between different management regimes in New Zealand vineyards, 24 vineyards were studied in the two regions – Hawke's Bay and Marlborough.

Vineyard soil was sampled from all these sites three times a year (budburst, véraison and harvest), every year for five years (2015-2020). We extracted DNA directly from the soil and analysed genetic 'barcode' markers for bacterial, fungal, and general eukaryotic (everything but bacteria or fungi) organisms.

Just like supermarket barcodes that are specific for products, these DNA barcodes tend to have a specific DNA sequence for different species. We analysed the 26.5 million barcodes sequences obtained, and this revealed the presence of around 12,000 species in these soils. We next determined if the numbers, types and relative abundances of species differed between vineyards with different management regimes using a range of statistical approaches. Overall, we found a small but significant effect of management regime on biodiversity. The number of bacterial species in conservation vineyards was, on average, 14% greater ($P < 0.05$) than in conventional vineyards.

There were also significant differences in the types and abundances of all species between vineyards with different management approaches ($P < 0.05$). In general, the soil biodiversity differences between management regimes explained around 1% of the total variation in biodiversity observed. Although small, this size difference is similar to the sizes of the difference in biodiversity between Marlborough and Hawke's Bay soils regardless of management approach.

The greatest variation in biodiversity was between years, which accounted for between 5-25% of the variation in biodiversity, regardless of management approach. We did not find any consistent differences between management regimes over time, indicating any affect that management approach has on biodiversity is probably dependent on another factor (e.g., if its dry, less spray might be needed, and conventional and conservation vineyards appear more similar), whereas the difference between regions was more consistent (Figure 1). Thus, there is a significant difference in soil biodiversity between management regimes, but this difference is relatively small and inconsistent, and the size of the difference is about the same as differences in soil biodiversity between regions.

These results are somewhat surprising and, on first inspection, go against the perception that the use of agrochemicals has a large impact on biodiversity. However, there are a few aspects that it is worth thinking about to help us understand these results and use the outcomes to inform decisions. First, the differences in biodiversity between management approaches are significant overall. The statistical analyses tell us there is a very low probability of observing these differences by chance: the biological signal for biodiversity differences between management approaches is likely 'real'.

Second, the amount of biodiversity measured using this comprehensive DNA analysis approach is enormous – there are more organisms in a kilo of soil than there are humans on the planet, and we found around 12,000 species here! So, while the differences between managements are 'small', this is relative; a small amount of something enormous still equates to a relatively large amount of biodiversity that differs. Third, we have measured what is there, but we have not measured the ecological roles of the organisms that differ. That is a much harder scientific challenge.

It may be that the most ecologically important species differ between management approaches, or they may not… we just don't know yet. Lastly, most studies on the effect of agrochemicals on biodiversity to date have not used DNA but have looked at one or a few key large species, like specific insects, and extrapolated the findings from these few species to all biodiversity. We have not done this – we have attempted to take the largest sample of biodiversity possible and then have analysed this. It is also worth highlighting a few other points. It is important to appreciate that the differences in biodiversity between management approaches shown here are not consistent. This suggests that any effect of management approach on biodiversity depends greatly on some other factors. Other parts of the VE programme are analysing as many aspects in these vineyards as possible to try and tease out what these may be. Also, all these vineyards are managed under sustainable credentials and so perhaps it is not too surprising that soil biodiversity differences are not large.

Lastly, we have only looked at soil biodiversity. The organisms in soil will have a significant bearing on soil fertility and carbon dynamics; the link between soil biology and fruit chemistry and quality is very poorly scientifically described, but it is likely that there is one. However, other work we and our research colleagues are doing is looking at microbial biodiversity on fruit, and the suggestion from these studies is that fruit-associated yeasts and bacteria are more greatly influenced by management approach, and this may have a larger bearing on fermentation properties and thus wine style (an interesting story for another article perhaps).

The take home messages here are positive. If you are a grower who is keen to try and change soil biodiversity, then the choice of management approach may help you do this to some extent. Further, if you are grower that also needs to ensure fruit yield and quality parameters are met, perhaps requiring the use of different input management approaches, then these data suggest any effect on soil biodiversity will not be too large.

ACKNOWLEDGEMENTS

The Vineyard Ecosystems Programme was a multi-year partnership (2015–2022) between New Zealand Winegrowers and the Ministry for Business, Innovation and Employment that was managed through Bragato Research Institute. The programme aimed to increase the long-term resilience and profitability of the New Zealand wine industry by developing new research-based approaches to pest and disease management resulting in significant increases in vine longevity. The New Zealand Institute for Plant & Food Research Limited and the University of Auckland are the main research providers. Additional research providers include Thoughtful Viticulture, Linnaeus Laboratories, South Australian Research and Development Institute, and Intecrop Ltd.