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A LIGHTER TOUCH®

Case study of biopesticides

Prepared for A Lighter Touch

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Executive summary

This case study report was prepared as part of the *Integration of Biologicals in Integrated Pest Management (IPM) Programmes* project under the A Lighter Touch (ALT) initiative. The aim of the case study was to identify lessons from the commercialisation and extension of biological crop protection products in New Zealand and provide guidance for product groups across the horticulture, arable, and winegrape sectors.

The primary case study identified for this work is Aureo Gold, a biological for managing Psa in kiwifruit. Its widespread adoption is a rare success story in biologicals in New Zealand, offering valuable lessons for enabling grower uptake. To broaden the learning, the study also includes examples from the apple and winegrape sectors: microbial products for the control of fireblight, pheromone products for the control of lepidopteran pests, and products for the control of mealybugs.

While these case studies emerged from sectors with different structures, market drivers, and levels of maturity with biologicals, common extension lessons can still be drawn. Key findings from the case study highlighted that the successful extension of biologicals depends not only on the efficacy of the product, but also on the system that surrounds its introduction. Extension outcomes are strengthened when:

- A collaborative sector environment exists, where stakeholders share a common understanding of the need for biological solutions and are aligned in supporting their development and introduction.
- Extension practitioners have access to technical experts to gain first-hand, unfiltered insights about the product. Ideally, some of these technical experts are also willing to be involved in extension events and can translate product insights into practical, grower-relevant messages.
- Grower-facing information about the products (e.g., benefits, constraints, mode of action) is developed with an understanding of their needs, perspectives, and the practical challenges growers may encounter when using a new biological.
- Messaging about the product is distributed in a unified and coordinated manner across a range of channels to reinforce the message and reduce confusion about the product.
- Efforts in this space are sustained over time, building trust and familiarity with biological products through repeated exposure and reliable information.

When delivering to growers, a combination of different extension activities should be used to reach a wide audience. For example, one-on-one advice from trusted technical or retail advisors plays a vital role, especially for less-engaged growers; peer-to-peer learning can be another influential channel, particularly when trusted growers share their own experiences; guided on-farm trials help build confidence by allowing growers to see performance in their specific context. Together, these methods create a comprehensive and responsive extension system that meets growers where they are.

Lastly, ongoing monitoring and R&D to refine the product and address challenges that arise post-launch should not be neglected to maintain product integrity and grower confidence.

Product groups vary significantly in size, structure, and experience with biological crop protection. However, some core principles have emerged from the case study that can guide all sectors. These

principles help build greater readiness and a stronger foundation for the extension of biologicals when opportunities arise. These are:

- Generate a wider grower understanding of biologicals.
- Nurture relationships within the sector.
- Identify or create the market driver and value proposition.
- Collaborate with other product groups.

Based on these learnings, an ***awareness and integration of biologicals checklist*** tool was developed. This practical guide helps product groups assess their product and system readiness and strengthen extension planning for extending biological solutions.

Awareness and integration of biologicals checklist

Part A: Product & System Readiness

1 Assess product fit and system readiness

Before investing in extension, ask: ***Is this biological a good fit for your product group, and is the system around it ready to support growers?***

A. Is the product viable?

Ensure **all** of the following are true:

- ☐ Is effective enough to address a gap or serve as an alternative to a chemical product, and this effectiveness has been demonstrated under New Zealand field conditions over several seasons.
- ☐ Can be integrated into existing grower practices, including ease of handling and application.
- ☐ Is viable economically.
- ☐ Is backed up by published independent research data and respected scientists / institutions.
- ☐ The supply chain is ready to meet the demand of your product group scale, should adoption increase.
- ☐ Its use is within the scope of the label approved by Agricultural Compounds and Veterinary Medicines (ACVM).

B. Is there a compelling value proposition for growers?

At least **one of the following** should be true:

- ☐ Helps growers meet market demand or regulatory pressures.
- ☐ Fills a significant gap in the current crop protection programme (e.g., can address a pest or disease threat).
- ☐ Offers unique advantages over chemical alternatives, such as being able to be used during sensitive crop stages or reducing the environmental impact of the crop.
- ☐ Aligns with your industry's long-term strategy or sustainability goals, which growers support.

C. Is the support system in place?

Success is more likely with more of the following in place.

- ☐ **Key players with influence on growers** (e.g., levy bodies, product groups) **publicly back** the product's use, agree on the key messages, and are happy to communicate the product to growers through their channels. Making sure this support is visible before rolling it out widely.
- ☐ **A coordinating body** is ready to lead / coordinate the extension and champion this product. Ideally, this consists of representatives from all key players in your sector.
- ☐ **Crop protection advisers** have opportunities to get their questions answered, understand how the product works, where it fits, and are confident in communicating with growers about this.
- ☐ There are **researchers or technical leads** who know the R&D behind the product and are willing to support communication efforts, answer questions, or help troubleshoot when needed.
- ☐ There are resources, or at least plans to bring in resources, to **gather and analyse data post-launch** to keep refining how the product is used, understand why it works (or doesn't), and support growers over time.

Awareness and integration of biologicals checklist

Part B: Extension Planning

2 Prepare your core messaging

Once you know the product and system are ready, develop answers to the questions growers are likely to ask. Test these questions and answers with trusted advisors who work directly with growers.

Prepare to answer the following:

- ☐ Why should I use this product? What's the benefit to me?
- ☐ How effective is it, and what's the evidence?
- ☐ What does the product cost? Where can I get it?
- ☐ What's the mode of action? When and how should I apply it?
- ☐ How does it fit into existing chemical / biological rotations to support resistance management?
- ☐ Are there use constraints (e.g. storage, mixing, expiry)?

Ideally, draw on local trial data from your sector's crops to answer these questions. If you don't have this, run some small on-farm trials with early-adopter growers to **generate sector-specific evidence.**

3 Plan your extension activities

Build your delivery plan based on your product group's strengths, resources, and trusted networks.

What in-person opportunities can you run with growers or advisors to talk about this product?

- ☐ Run your own workshops, field days, etc.
- ☐ Partner with research providers or commercial companies to co-host.

Who are your trusted advisors and grower champions (by crop / region)?

- ☐ Identify advisors or growers who can help communicate the product with credibility.
- ☐ Book technical experts or researchers to support these events and answer technical questions.

What support can you give growers who are keen to use this product?

- ☐ Offer guidance to help ensure on-orchard trials are as robust and informative as possible (without being overly scientific or complex), such as process checklists and templates.
- ☐ Providing supporting technologies, such as pest and disease monitoring tools, is advantageous
- ☐ Establish simple ways for growers to collect and share results (or informal learnings) with you.

What materials should be developed?

- ☐ Think about decision support tools, FAQs, or case studies.
- ☐ Ideally, materials should range from summaries to more technical info, depending on the audience. Prioritise easy-to-digest information that is supported by visuals if this is not feasible.
- ☐ In particular, capture the growers' voice, especially in good use examples

What communication channels can you use to spread the word or share resources?

- ☐ Think about newsletters, grower portals, crop manuals, social media, and websites.
- ☐ Don't forget in-person opportunities like workshops, field days, or industry events you're already running or contributing to.

Introduction

Background

Integration of Biologicals in IPM Programmes

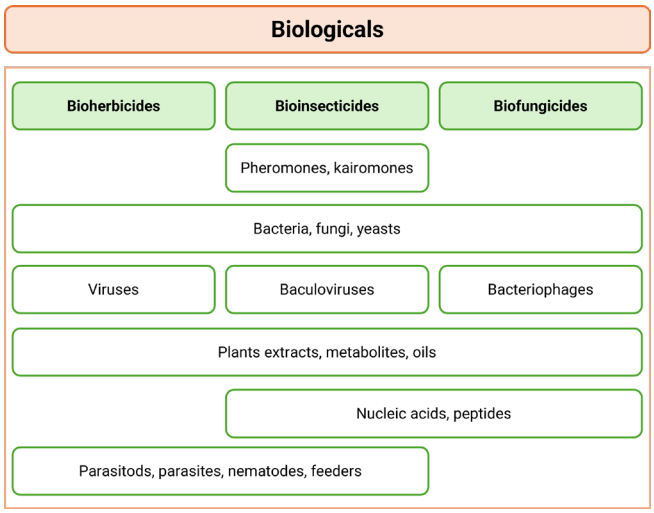
A Lighter Touch (ALT) is a $27 million, seven-year programme jointly funded by government and industry. The programme addresses the challenge of helping growers / farmers / producers (hereafter, called growers for simplicity) transition to agroecological crop protection, ensuring the long-term sustainability, economic viability, and global competitiveness of New Zealand's agricultural sectors. It has been funded through the Ministry for Primary Industries (MPI) Sustainable Food and Fibre Futures Programme.

The *Integration of Biologicals in Integrated Pest Management (IPM) Programmes* project has been developed to provide accessible and usable resources (guides, people / experts, tools), through collaboration with ALT partners, to build confidence and increase uptake of biologicals. The project has three streams of work to fulfil the project goals: supporting biological extension work, an extension capacity and capability needs map, and a retrospective case study on the successful commercialisation of biologicals to identify learnings. This document outlines the **retrospective case study**.

Biologicals definition

The definition of biologicals can often be ambiguous; for clarity, the definition of biologicals used in this case study is defined in Figure 1.

Figure 1: Biologicals definition



Market and regulatory context for biologicals in New Zealand

To give some context on biological extension currently, growers are generally aware that the increasing global use of biologicals is the preferred route for a more sustainable food production system. However, growers want biologicals to have similar efficacy and cost to the chemistry they have been using to date. Biologicals generally do not meet these criteria. The average efficacy may only be around 60-70% or less, compared to 90% for currently used products, and they are more expensive. These are some of the barriers to the uptake of biologicals.

In addition, New Zealand has a slow and restrictive regulatory system for agrichemicals. This means some companies are reticent to enter the New Zealand market with new products, let alone biologicals. The relatively small size of the New Zealand market exacerbates this problem. To get registration, a minimum of two years of field trials in two New Zealand locations is required for the data package. Overseas field trial data can support the application, but greater consideration of this overseas data in the review process has been a consistent request from industry stakeholders (G. Pringle, pers. comm. May 2025). At the time of writing, neither of the New Zealand regulators (EPA and NZFSA) has a specific pathway for the approval or registration of biopesticides. Biological control agents are assessed under the parts of the HSNO Act that govern new organisms, which adds additional complexity not typically experienced in other jurisdictions. As a result, biologicals are not treated any differently from chemical products in the registration process, despite their distinct characteristics and potential risks.

Biological extension

Extension is the process of enabling change in individuals, communities and industries involved in the primary industry sector and with natural resource management. The role of extension is to accelerate adoption by reducing the time and effort growers must invest in learning.

While growers generally are more aware of the global shift toward more sustainable pest control methods, the adoption of new products such as biologicals often hinges on appropriate extension support. There is a great variation in the understanding and experience of growers with biologicals. Experience has shown that those who have poor experiences with biologicals are often those newer to them, or have had an unsuccessful experience with them in the past. Extension efforts need to balance the need for technical information with the practicalities of using biologicals. Therefore, extension messages must be clear, concise, consistent and sufficient to ensure proper use and the best outcomes from biologicals. This is particularly relevant to family-owned businesses where growers are often very busy or may not have access to expert advice in crop protection. Corporate growers tend to have their own in-house expertise or access to expertise as needed.

Overview of the case study work

Objectives

The specific objectives for this case study work are to:

- Understand how the extension of past biologicals – particularly Aureo Gold – was carried out, and how this compares to the success factors identified in the extension literature for biologicals in crop protection.
- Draw practical lessons for extension from these cases to support product groups in helping their growers realistically integrate biologicals into their pest management programmes.

Scope and contextual considerations

Aureo Gold was selected as the primary case study for this work, a biological for managing Psa in kiwifruit. It was selected as it was a biological where the development, commercialisation, and extension process was effective in supporting widespread use. However, we acknowledge that its success reflects a combination of favourable circumstances: a particularly robust biological organism, the urgency created by the Psa crisis, the strong export demand for kiwifruit, and the support of a well-resourced and cohesive industry.

These factors are not easily replicated in other sectors, particularly in vegetables and arable crops, where profit margins are lower, export incentives are fewer, and biologicals are less commonly available. To provide a more nuanced list of extension lessons, the scope of this case study was expanded to include insights from three additional examples:

- Microbial products for the control of fireblight in the apple sector – these products are a mature example of the use of biologicals in the apple sector with high levels of adoption, uptake, and trust from growers, which is why it was selected. Like Aureo Gold, it was borne out of an interest in biologicals after a particularly bad year for fireblight in the 1980s.
- Pheromone products for the control of lepidopteran pests in the apple sector – these products have been a staple in the industry for some time and are widely adopted in comparison to other biologicals. However, they were not borne out of an emergency. These products stemmed from a sector-wide shift from non-selective to selective pesticides in the 1990s.
- Products for the control of mealybugs in winegrape – compared to the previous examples, these products have been released more recently but have had very little adoption and uptake despite the production-driven economic drivers. These were selected as an example of a sector with less of a history using biologicals and less trust from growers with these products.

Insights derived from these case studies were further explored in relation to other crop sectors to ensure relevant and useful lessons for extension were generated. This exploration helped ensure the findings had practical applications across the product groups involved in A Lighter Touch (see Supporting the awareness and integration of biologicals on page 20).

It should be noted that while biologicals are central to this work, we are not promoting any single product. Instead, we explore how different industries supported growers through coordinated extension and draw lessons that could help other product groups and sectors improve how biologicals are introduced and adopted. It's important to recognize that products like Aureo Gold are not a silver bullet. Like any treatment, they form just one part of a broader crop protection programme. The performance of biologicals is influenced by multiple factors, including product timing and complementary use of other inputs (e.g., copper).

Finally, the factors identified from the literature review, the Aureo Gold case study, and other biologicals experiences demonstrate practices that have proven successful in specific contexts. These factors should not be viewed as a rigid blueprint. While not all sectors will be able to fully or immediately adopt these practices, they provide a valuable starting point for developing realistic and effective extension strategies for biologicals.

Methodology

This case study was constructed and analysed by conducting a literature scan and a series of stakeholder interviews, including nine focused on Aureo Gold, seven in the apple sector, seven in the wine grapes sector, and two covering both the apple and winegrape sectors.

Literature scan

This included a range of literature from journal articles and research papers to news articles and podcasts around Aureo Gold and the extension for biologicals, and focused on the questions below:

- How successful was Aureo Gold?
- How did the extension and commercialisation of Aureo Gold occur?

- Who were the key players in this process?

This process allowed us to gain a greater understanding of the context and specifics around Aureo Gold to inform the case study and interviews. It also allowed us to identify the key stakeholders for the subsequent interviews.

Interviews on Aureo Gold

The nine interviews were conducted with the key stakeholders across various organisations. Some interviewees were initially identified through the literature review, with subsequent interviewees recruited through snowball sampling. The interviewees included:

- Three independent consultants / technical managers
- Two from Zespri
- Two from Plant & Food Research (PFR)
- One from Kiwifruit Vine Health (KVH)

These interviews spanned from 30 to 60 minutes and were conducted online. Each interview was semi-structured to ensure flexibility for each interviewee's areas of expertise.

Interviews on biologicals in apples and winegrape

An individual from Research & Development Management Ltd. was identified as a key figure in the development and commercialisation of Aureo Gold, along with other biological crop protection products, for the New Zealand market. He was later contracted to contribute to this study by selecting the additional case studies in the apple and winegrape sector. As part of this work, he conducted 15 interviews, with participants across the following categories, some interviewees had multiple roles:

- Four from agrichemical companies
- Five from retail / technical / consultancy services
- Two from research organisations
- Three from sector body organisations
- Three growers

His involvement allowed us to expand our case study scope beyond Aureo Gold to include other examples of biologicals in the apples and grapes industries. These interviews were also semi-structured and conducted online.

The data from the interviews were analysed thematically and collated into themes. Selected interview quotes are included throughout, with minor edits for clarity. Given the small sample size and the fact that many participants hold multiple roles (especially at the time of product development and these interviews), quotes are presented anonymously to maintain confidentiality.

Case study findings

The following section details the learnings drawn from the interviews with stakeholders involved in the development and launch of the above biologicals in the kiwifruit, apple, and winegrape sectors.

Creating an enabling environment

Our research revealed that an enabling environment was created during the development and commercialisation phase. These elements were established before any grower-facing extension activities occurred, setting the foundation for improved extension outcomes.

Extension needs to be backed by a collaborative sector

Extension success requires collaboration and stakeholders who share a common understanding of the need for biological solutions. In the case of Aureo Gold, the foundation for this collaboration was laid during the Psa crisis, which prompted the formation of a cross-organisational working group focused on disease management. This group was led by KVH and brought together all the key industry stakeholders, including Zespri, NZKGI, post-harvest operators (e.g., Seeka), government agencies, and research and commercial partners like PFR and UPL. The group came together regularly to share research results and investigate possible solutions. Each representative involved was able to act as a champion, helping to bring the rest of their organisations on board.

While this group was not formed specifically for Aureo Gold, the collaborative environment it fostered was critical to the product's later development and rollout. The strong relationships and trust which developed enabled open and honest conversations within the group, including addressing challenges such as negative trial findings, product constraints, manufacturing costs, and business risks. Interviewees noted that even for Zespri, this represented a big commitment, as they typically do not invest in agrichemical or biological product development where there were no commercial benefits in doing so (i.e., IP). However, everyone was able to focus on getting the right solutions to growers and appreciating each other's needs. In this case, Zespri contributed alongside other parties to the cost of development, which was also supported by government funding. For UPL and PFR, the collaboration extended beyond product development to building relationships with the entire kiwifruit industry. This broader perspective helped resolve challenging issues.

> *Working as a team, this is where it became quite different from other examples and led to [Aureo Gold's] success. We had scientists, the agrichemical suppliers coming in to co-fund and do some research, and exporters funding as part of the innovation programme – which was quite unique. With funding, we were doing more research and getting more information, which sped up the process. It was that uniqueness that got the award [at the NZ's Kiwinet Innovation Awards 2021[1] and World BioProtection Summit and Awards 2022[2]]. It was not the innovation around the product, but the innovation around how it all worked and how it was developed.* Industry stakeholder interviewee

The collaborative approach has continued to underpin the kiwifruit industry's response to crop protection and biosecurity. Sector-level groups such as the Kiwifruit Biosecurity Steering Group work to reduce the risk and impact of biosecurity incursions. One interviewee also reported a Crop Protection

[1] https://kiwinet.org.nz/Awards/Awards2021
[2] https://kvh.org.nz/newsroom/aureogold-wins-at-world-awards

Steering Group, which brings together technical managers from all major post-harvest organisations, along with Zespri and KVH, to share research and communicate learnings.

In the apple sector, the relationships among corporate entities and between individuals are reported to be positive, open, and bilateral, providing a good foundation for the introduction of the mentioned biologicals. In recent years, NZAPI has been fostering communication through its Agrichemical Advisory Group, which was set up a few years ago to oversee products and their emerging issues (regulatory, resistance, growers, product integrity, residues, efficacy) with representatives from research, wholesale, retail and grower entities. Interviewees reported a high level of connectedness, along with the occasional 'firewall' to respect commercial interests and NZAPI membership.

The wine sector is generally more prescriptive of product use, arguably more so than the apple or kiwifruit sectors. New products such as Desire Mealybug lacked industry-led market priming. Its adoption has been largely driven by the efforts of researchers with limited or no support from other actors in the value chain, or enthusiasm and receptiveness from the sector bodies. Several knowledge gaps regarding the product use (e.g., the identification of the life stages of mealybugs, interpretation of trap catch results, trigger points for intervention) haven't been addressed since the product has been made available. These dynamics make it more difficult for sector-backed extension of biologicals to operate effectively.

What can undermine this:

Sector-wide collaboration can suffer when **individual stakeholders prioritise their own objectives**, particularly commercial interests. This can result in biased support (e.g., based on product revenue potential), while information sharing becomes limited by commercial barriers. Such behaviour reduces other stakeholders' willingness to collaborate and risks alienating growers, who often prefer independent, non-commercial data sources.

Effective extension requires access to experts with a system view

One of the key relationships for any sector in the extension of biologicals is the main extension deliverer(s) (usually part of the sector body) and the manufacturers and researchers behind the products. When these relationships are strong, advisors and extension practitioners can gain first-hand, unfiltered insights and are able to share up-to-date information with growers.

For example, we heard reports that Zespri's crop protection team maintains good relationships with agrichemical manufacturers. They will get together regularly and talk through newly developed products. This allowed the team to get first-hand information about the products and ask questions directly. In the case of Aureo Gold, both Zespri and KVH were part of the early development process and able to build strong relationships with key figures in Research and Development (R&D) over time. They would call on these relationships later to help refine extension messages. They were also able to adapt the fact sheets manufacturers developed, invited scientists as speakers to their grower-facing events, and undertook field days on their trial blocks. This access was extremely valuable, allowing the extension practitioners in the two bodies to confidently develop resources for their growers and plan for the rollout of Aureo Gold.

> *An important part has been utilising in-person. The Plant & Food researchers … have done tons of face-to-face contact with growers. This has been critical. As the developers of the product, they are more familiar with it than anyone else. And as scientists, you expect their contributions to be robust and reliable.* Industry stakeholder interviewee

Similarly, in the apple sector, PFR is the primary supplier of high-level science. They are often contracted to do comparative field trials for biologicals for NZAPI, and their reports are available in a secure section of the NZAPI website. They will present related findings through the annual conference of the New Zealand Plant Protection Society, as well as at sector field days and events.

PFR[3], as a reputable Crown Research Institute, has played a key role in the development and rollout of several biologicals included in this study (e.g., Aureo Gold, Blossom Bless, Desire Mealybug, Isomate 4Play). Scientists and researchers at PFR are generally seen as trusted experts by the sectors and growers. A few notable scientists identified by interviewees were highly respected advocates for IPM. They are also known for their ability to blend deep scientific knowledge with commercial understanding, an approachable personality, and fit-for-purpose presentation style. The Fruitfed Supplies Technical Extension Team (within PGG Wrightson) also stands out in that they proactively and regularly visit agrichemical sources overseas for updates on new and existing products. However, while several sectors have benefited greatly from the contributions of these individuals / teams, it also highlights a vulnerability. It was noted during the interviews that several key experts that have a mix of technical and commercial experience have recently retired or are nearing retirement. This raises concerns about continuity and highlights the need for intentional succession planning and training to sustain these capabilities into the future.

A similar issue applies in the extension space. One interviewee pointed to the importance of champions who not only understand the technical aspects but also have the passion to deliver them to growers effectively. They named a few current professionals in the sector who they considered as examples of those figures, describing them as great "storytellers and visionaries". This interviewee urged the fostering of these champions of biologicals in all sectors, with these qualities to inspire and push the sectors forward.

> *Animal and Plant Health is doing a good job right now, trying to break down barriers, and how we put sustainable products in growers' hands [through grower-facing extension activities]. They've really ignited members of all sectors to bring it to the ground. [Name of staff] is passionate – she would come in and help. Where would we be if we didn't have the big thinkers and the passionate growers willing to take it to the next level… Bring in the old guys who've recently retired as models.* Industry stakeholder interviewee

What can undermine this:

Access to experts can be limited by **institutional silos**, **commercial or research sensitivities** (e.g., interviewees noted that some technical professionals would like more extensive access to PFR trial sites, but the contractual agreements between NZAPI and PFR may be a barrier to this), or as mentioned above, **personnel changes** due to retirement. These can **prevent extension practitioners from accessing the necessary underpinning knowledge of the product and pest** in order to develop better resources and communicate with growers (e.g., the phenology of pest growth, why a product may fail). This could lead to mixed messaging across the value chain, increase the chance of misuse of products and degrade grower trust in biologicals as a whole.

Extension requires a strong understanding of growers

Another critical relationship that was emphasised by many interviewees for the successful uptake of new biologicals was the relationship between the sector body and the growers. Building this trust

[3] Now part of the Bioeconomy Science Institute, which brings together AgResearch, Manaaki Whenua – Landcare Research, Plant & Food Research and Scion into a single organisation.

requires the extension practitioners to demonstrate that they have a deep understanding of growers' needs, perspectives, and on-the-ground realities.

In the lead-up to Aureo Gold's launch, both KVH and Zespri invested significant effort in understanding the product's benefits, constraints, mode of action, and anticipating how it would be received by growers based on their experience. They were able to develop pre-emptive answers to address growers' questions based on their experience. More importantly, growers themselves were actively involved in the process. Some participated in industry working groups, providing a valuable channel to gather feedback and questions directly from the grower perspective. Others were involved in product trials and brought back practical questions about tank pressure, spray behaviour, and so on, which often aren't typically addressed during a product's registration phase. As a result, by the time the product was launched, growers already had access to a wide range of relevant information and didn't have to jump through hoops to get the answers they needed.

> *All the labels, what can I mix it with, how compatible is it, can it go with bees, residue risk, toxicity risk with neighbours, were all laid out. Where can I buy it, how do I store it, do I need specialised machinery, etc. Knowing all of this at once is the most important.* Industry stakeholder interviewee

Interviews with stakeholders from the apple sector echoed many of these points. They highlighted the importance of understanding in advance the questions, concerns, and practical challenges growers may encounter when using a new biological. For example, there are nuances to the choice and use of Bt products in terms of target pest and use patterns. Product 'failure' often occurred not because the product itself was ineffective, but because it was used incorrectly, either due to growers involved not being given the necessary information or not engaging with it. In both cases, extension has a role to play. The horticultural and winegrape sectors in general rely heavily on contract or seasonal labour. These workers' needs in this space are even more pronounced as they are often less likely to have experience with biologicals or a personal stake that encourages careful use of the product. Providing clear and practical guidance for everyone involved in the application process from the start is critical.

What can undermine this:

A challenge in this space is if extension fails to engage **growers who are more hesitant about biologicals.** This is often due to previous bad experiences with "snake oil" biologicals from misrepresentations of product efficacy or relying on tried-and-true products. Feedback gathered from growers to be used to develop extension resources tends to come from those who are more familiar with biologicals or are more vocal. This risks overlooking the concerns of these more reluctant or quieter growers and results in resources or messaging failing to resonate with the broader grower base. Furthermore, the 'rumour mill' among growers can be very influential; negative stories can travel without much challenge from independent parties.

Extension needs to lead a unified messaging

Once extension has the backing of all the key players in the industry, access to experts, and a clear understanding of what growers need to hear, unified messaging about the product across the industry needs to be coordinated. Without it, as with Desire Mealybug, confusion and frustration can arise, ultimately leading to the product being deemed "too hard" to be used and subsequently ignored.

In the kiwifruit sector, industry messaging was considered an integral project output for dealing with Psa from the start. This has benefited the extension of Aureo Gold, as consistent messages from sector bodies and other organisations across the value chain reinforced the product's importance and gave

growers confidence to adopt it. Overall, the extension of Aureo Gold was led by Zespri, as the industry body and the gatekeeper of the industry's Crop Protection Standard, and KVH, as the lead agency for Psa management messaging, with strong connectivity with UPL, as the product supplier. This distinguished Aureo Gold from other less successful biologicals that lacked the same level of coordinated promotional support behind them.

> *The problem is when people separate themselves out as being the experts, you get turbulence – we had already experienced that, so we thought we needed to come together to say it once, say it clearly, and if we say it secondly, it should be the same as the first.* Industry stakeholder interviewee

Similarly, within the apple sector, the messaging around product preferences, performance, and use is reasonably consistent between NZAPI, the retailers, agrichemical companies, and research providers. There are occasional mixed messages from different individuals in the research community and commercial preferences for those with an interest in product sales, but NZAPI often has a moderating effect on these. At the end of the day, every actor in the industry wants the right product to be successful. Interviewees commented that the apple industry is one of the better ones for this, compared to some other crop sectors, which may be more reticent to share information.

Importantly, effective messaging also means tailoring the level of detail to the audience. Interviewees have varied views on this, though the consensus is that practical and easy-to-digest information, supported by visuals, should be prioritised for growers. The best approach, if resource allows, is to provide layered communication from concise bullet points to deep explanations so that they are readily available to cater for different learning preferences and needs.

What can undermine this:
A unified messaging needs all of the previously mentioned factors to be in place to be possible. When extension is not positioned to align messaging, it can lead to confusion, misuse or dismissal of biologicals that might otherwise have been successfully integrated into growers' practices.

Long-term consistency builds foundational trust in the extension of biologicals

Extension of biologicals is more successful when they can build on long-term trust with growers. Trust in biological solutions isn't built overnight. Consistent exposure to effective biologicals helps growers gain confidence in both the products and the system (i.e., the information being passed on to them from the sector bodies). The apple sector's experience shows how sustained investment in biologicals can gradually build deep trust among growers. Since the 1990s, apple growers have been introduced to a sequence of biological tools from pheromone-based monitoring and mating disruption control products to selective insecticides, followed by Bt products and then baculovirus products. This demonstrated the sector's long-term commitment to integrate biologicals into growers' pest management systems, and it did so effectively by offering reliable products. As a result, apple growers are more open to biological innovations than some other sectors.

This achievement also reflects the role of a clear, long-term industry vision. Similarly, the kiwifruit industry, particularly Zespri as the sector body, also has a very clear goal of being the world's leading provider of premium kiwifruit, with a strong emphasis on sustainability and health. This strategic direction created the right environment for the extension of biologicals to thrive because growers understood not just what product they were being asked to adopt, but also how it supports the identity and competitiveness of their sector.

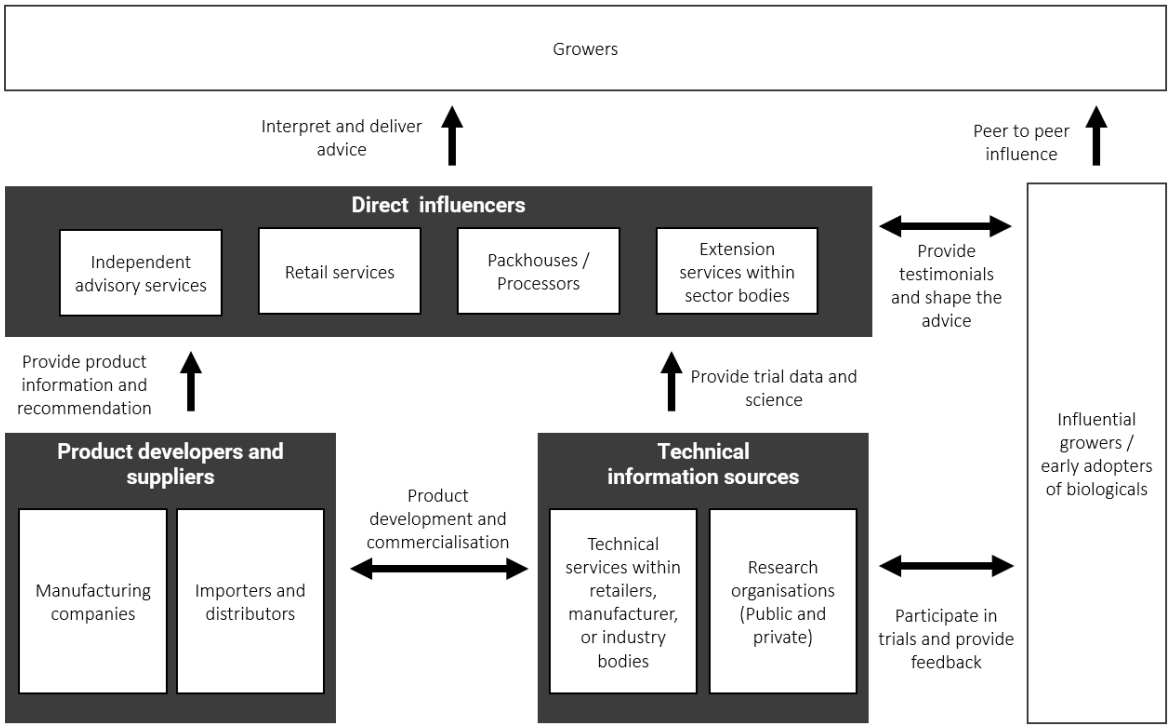
What can undermine this:

Long-term consistency in both the crop protection and extension space to build grower confidence can be disrupted by **changes in industry priorities** (or key champions), **short-term funding cycles for biologicals** (without legacy or sustainability plan), or **poor or absent monitoring of products and targets in the long term** to ensure the reliability of biological practices.

Employing a combination of extension methods

Interviewees reported a combination of extension methods being used across different organisations to encourage the adoption of the biologicals. Figure 2 below illustrates the typical information flow through the horticultural, arable, and winegrape sectors. It was developed based on insights gathered throughout this study and depicts how crop protection products and information are introduced, interpreted, and ultimately adopted on the ground at a high level. Key actors who tend to have the most direct influence on growers include independent consultants, sales reps, post-harvest organisations, and the specialised extension team within sector bodies. These actors operate within a broader ecosystem that supports them, including product developers, suppliers, and research institutions. Understanding these pathways of influence can help clarify what impact different extension methods tend to have. Building on this, the following section explores the delivery methods highlighted by the interviewees.

Figure 2: Key influencers in extension



One-on-one advice from trusted advisors

Across the sectors, growers often make decisions about crop protection products based on advice from trusted individuals with whom they might have developed relationships over decades. As captured in Figure 2, they can be categorised into four groups. Although the level of influence specific influencer

groups hold may vary between sectors (e.g., Zespri having greater influence on kiwifruit growers compared to other sector bodies, while vegetable growers rely more on their processors than kiwifruit growers do on their packhouses), they all remain a powerful channel for extension. These influencers understand each grower well enough to tailor their messages and deliver them in the most appropriate setting. For example, growers and their go-to merchants might talk about new products over a cup of tea. This can be particularly valuable to help reach less-engaged growers.

However, for this method to work well, these advisors must be equipped with the best education and support. This includes access to data from field trials and detailed information on the mode of action, which in turn helps growers understand how to use biologicals effectively. As with some other types of actors in the value chain, there is variation in the receptiveness of some advisors to biologicals.

> *There's also the post-harvest communities / facilities and their reps, and you hope that they can influence their grower clients. And also, retailers with grower clients. These people can help push "the stragglers" growers to pick it up. Just making sure you had the range of these people going to the meetings to hopefully get the message out.* Industry stakeholder interviewee

Peer-to-peer learning

Extension also often occurs between growers themselves, particularly between influential growers in the sector who are established as 'early adopters' of biologicals or their vocal supporters and other growers (see Figure 2). A way to foster this connection is to enable peer-to-peer learning. The kiwifruit industry often has a large annual grower event, with other smaller ones throughout the year, where growers can connect with each other and share information. Zespri also organises regional grower meetings (e.g., Shed Talks) as a chance for growers to discuss news in the industry and have their say. These grower events are timed well for when growers are less busy and happier to take time off.

> *If you are hearing it from other growers as well, it can be very powerful. Pick a time that is quieter and when people want to catch up. The in-person, quiet opportunities to get together and go out into the fields work pretty well.* Industry stakeholder interviewee

One interviewee highlighted another method of fostering peer-to-peer learning through spotlighting their top 10% of growers. It's a way to celebrate them but also to highlight their use of biologicals and the success they've had using them.

> *Using that knowledge, we can lend some extra weight to the extension messages in terms of just saying, hey guys and girls, this is what our top 10% of performers are using. This and this are why we are recommending it… this product range and these product options, and the timings… it just lends a bit of weight and credence to the extension messaging if you can support it with science and what the top performers are doing.* Industry stakeholder interviewee

These forums for peer-to-peer learning can form and be led and maintained by growers themselves and other actors in the value chain, but they need a continued purpose or support mechanism to be sustainable. One historic example is the regional grower IPM groups within the apple sector to which most growers belonged. These groups fostered collaboration and bolstered an innovative mindset. Each group consisted of regular meetings with a facilitator and around 15 to 20 growers, including other actors in the value chain. However, these groups gradually disbanded as growers grew comfortable with IPM.

Field observations

Industry-specific trials were considered fundamental to provide another layer of evidence of whether the product is suitable for their crop. Particularly for locally developed products, which may have less background information on them, often due to limited development resourcing compared to synthetic products by large multinational agrichemical companies. Interviewees reported that these local trials are highly valued by growers for demonstrating both the absolute and relative field efficacy against the target pest or disease. These trials are also considered by many interviewees as one of the most effective channels for extension and should be prioritised. For example, during the trial period, PFR prioritised testing Aureo Gold on commercial blocks. These commercial blocks were available for Zespri to run field days so that growers could come along and see the process and results and ask questions. This helped the relationship building with growers and enabled them to pick up this new product quickly.

> *[If a sector could only invest in a couple of extension activities] I think it would be trying to pack as many of those resources as possible into one or two sessions with growers directly. A workshop or field meeting with the scientists, and whoever is funding the science, to present the technical information and how it's been developed, then invite growers, merchants, and reps to that meeting. Ideally, have a field component so you can actually see how or where it is.* Industry stakeholder interviewee

In the apple sector, field trials are conducted by PFR, agrichemical companies, and the FruitFed technical group, with many of them having scheduled open days or supplier visits. FruitFed alone conducts up to 20 regional grower meetings each year, which review the last season's environment and outcomes as well as the trial data and look to the next season.

Despite being widely recommended, interviewees also suggested that caution needs to be taken when using or introducing results from field trials at a small scale with many uncontrolled or unrecorded factors that could contribute to the product performance. This has added considerably to the distrust of biologicals, generally and specifically. Where possible, conducting trials at a larger scale, such as using larger plots, can minimise the risk. Additionally, an opportunity also exists in supporting the local data with overseas data, as biologicals are often impacted by inconsistent small plot field trials prior to market entry.

Training

In-person group events with an educational or training purpose are among the most widely used extension methods in general. For example, both Zespri and KVH had delivered a range of grower seminars and grower days, where Aureo Gold was either the focus or part of the agenda to encourage the uptake of the product. These events enable a group of growers to access information at once and provides opportunities for them to ask questions and connect with each other.

Even though it has been a go-to choice for many sectors when it comes to extension, several interviewees highlighted the importance of how the session is delivered and the educational message is relayed. Researchers do not always speak the right language for the grower. Therefore, it's essential to involve someone who can explain the information in a way that makes sense to growers (e.g., what it means on my orchard / farm). At the same time, it's also important to include technical experts who can answer more detailed or complex questions. For example, during the Aureo Gold events, scientists from PFR and experts from UPL were consistently involved in giving presentations and / or answering growers' questions during discussions. This made sure questions coming from growers (which could

still be very technical) could be answered on the spot as much as possible to increase that buy-in. Having both types of contributors in the room helps ensure the training is both relevant and credible.

> *An extension team, including a subject matter expert, is very important when delivering information to growers, rather than someone working off a sheet with bullet points. You have to be able to answer questions when you have the growers in the room to get that buy-in.* Industry stakeholder interviewee

Additionally, training and extension are not limited to sectors that have low uptake of biologicals. Sectors with mature biocontrol products often have little new information being generated around their use, complacency can and does set in, risking pest and disease outcomes. As such, extension must be continued, especially for new generations of growers.

Information provision

To supplement the real-time events, a suite of resources for growers and advisors (from very technical to a sales sheet) to refer to was developed for Aureo Gold. Moreover, they could access / receive information regarding Aureo Gold from a variety of channels across different organisations. For example, KVH Psa forums, various websites, Zespri crop production manual, innovation research days, etc. This multi-layered communication approach helped ensure consistent messaging and gave growers flexibility to engage with the material in their own time.

> *I think the kiwifruit industry is very well networked, there are multiple channels to deliver messages, in different ways that a grower might respond to. Kiwifruit Vine Health has the leading responsibility for communicating in this space and is well supported by Zespri, who have oversight on spray diary and Crop Protection Standard. There are workshops annually for changes to the production standard that are widely communicated. They have also organised technical experts to communicate the new research outputs and what they have been learning.* Industry stakeholder interviewee

Growers prefer accessing field trial data and preferably data independent of vested commercial interests. Insights from the apple industry further emphasise being strategic about how the information is presented (or to prioritise when resources are limited). For example, annual field trial reports are detailed and credible, but some growers often don't access them due to time constraints, let alone keeping up to date with them year-on-year. There is an opportunity for a meta-analysis of trials over the years and combined with a light-touch commercial data-based post-market analysis, to build a more thorough picture and be delivered in a one-stop shop format.

Additionally, practical / instructional materials are valuable, such as the Decision Support Systems provided by NZAPI, which guide growers to time the use of crop protection products for key pests based on pest phenology and environmental conditions. Likewise, case studies from other growers, even those documenting failures, can help build practical understanding and establish lessons learnt. Without these instructional materials, the effectiveness of biologicals can be undermined. For example, interviewees suggested that biologicals can be put into a box of 'late season use only' when there are no options for synthetic chemistry, limiting their equally applicable use as a preventative measure early in the growing season. Biologicals can then unfairly develop a reputation of being ineffectual because of high pest or disease pressures, where even synthetic products may be equally ineffective.

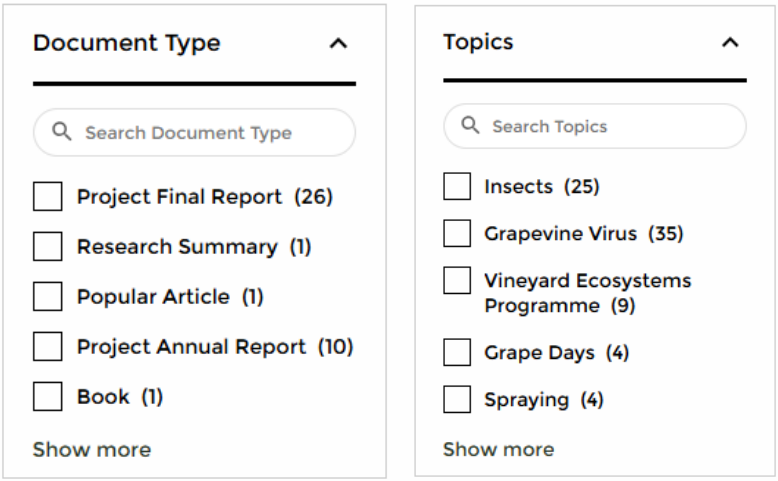
For resources to have an impact, growers must be able to absorb the information. However, due to their often-busy schedule, the resources may be pushed to the back of their mind, lost, or not applicable yet due to timing. Repetition is important in these cases, sending out the resources again, reminding

people about links to resources, and even arranging short form reminders at critical times of the growing season about use.

> *[Having] the quick, short, punchy messages backed with a bit of science rather than going into a long-winded story and then just repeating, repeating, and then repeating some more. Repetition of messaging is quite important; you can't just say it once.* Industry stakeholder interviewee

By way of example, the information resources made available to the winegrape sector on mealybugs cover varying levels of detail from research reports to technical notes (Figure 3). These resources are searchable on their secure website.

Figure 3: Example of resources relating to mealybugs available in the winegrape sector



Guided on-farm experiments

Interviewees reported that encouraging growers to trial the product on a small part of their own orchards as part of the extension and education was very important in leading to adoption. First-hand experience helps build confidence and demonstrates how the product performs under their specific conditions. However, interviewees highlighted that this process should be supported as growers may not know how to do a robust trial process on their own, such as analysing and interpreting data and results.

> *Having a good statistician is good – engage the young growers and the future leaders. Supporting them in the process of doing the trial, how to collect results, and providing them with someone who knows how to crunch the numbers. Or have a list of people available to do that job for them.* Industry stakeholder interviewee

While some interviewees acknowledged that these trials are often not scientifically rigorous, it doesn't necessarily diminish their value, as the key is to show that the product works under real-world commercial conditions (or not, and why) in an accessible way that growers also trust. Of course, there is still the assumption and need for the grower to understand and apply the product correctly, and this is where having the process supported by an expert (or at least having the option to do so) can be valuable. There can also be logistical constraints to collecting data from this activity, especially among larger corporate growers.

Undertaking continuous post-market monitoring

Lastly, ongoing monitoring and R&D to refine the product and address challenges that arise post-launch is important to maintain product integrity and grower confidence. This refers to a light approach to gathering quantitative data on product use, performance and impact to share within the industry, which adds additional layers of knowledge about the product across different microclimates and orchard systems. Ineffective outcomes from the use of biologicals need to be investigated on a commercial scale. However, it is also essential to note that numerous factors contribute to these poor outcomes.

In addition to more outcome-focused monitoring, tracing the viability of the microbial products after application could also provide more insights and enhance their performance. While quality control is assumed up to when the product is taken from its container, less is known about how well these organisms survive once applied.

For Aureo Gold, interviewees reported that more research was supported by the industry to understand additional modes of action and synergistic action beyond its launch. For example, further trials looked at how Aureo Gold could be used alongside copper sprays (they can't be tank mixed together, but how soon after or before copper can Aureo Gold be used) to make it more user-friendly. For the apple industry, recently, NZAPI created a new role that is dedicated to analysing data routinely collected in the crop protection space. Before this, the last sector-wide analysis of crop protection was in 2014. There is also a current SFFF-funded project looking at fireblight biocontrol products, which will provide further data to inform product development and extension.

The sector bodies studied for this report now have dedicated staff analysing production and spray information. This should add greatly to the experience of biocontrols and factors that contribute to good performance.

Supporting the awareness and integration of biologicals

Product groups across horticulture, arable, and winegrape vary significantly in size, structure, and experience with biological crop protection. We acknowledge that not all lessons from this case study can be applied universally or immediately. However, some core principles can still guide all product groups toward greater readiness for the adoption of biologicals.

- **Generate a wider grower understanding of biologicals,** including the generic features of the various biological project types via a range of extension methods outlined previously, trade literature, and using overseas and local examples of best practice and impact.

- **Nurture relationships within the sector.** For product groups without a strong sector body, extensive capability and capacity resources, or many biological options, start by strengthening relationships within the sector. This could be through more outreach and engagement, so that there is a sector-wide collaborative foundation for extension if opportunities arise.

  One example to implement this is through establishing regional grower groups and ensuring crop protection / biologicals is one of the focuses for these groups. The group should include a variety of stakeholders from across the value chain to bolster collaboration and peer-to-peer learning. Over time, these can grow to be more self-sufficient but will need support to be established and generate value.

- **Identify or create the market driver and value proposition.** Biologicals may not always be cheaper or more effective than conventional methods, but sometimes they are still the best, or only, option that will fit market and regulatory conditions. Many interviewees noted the tighter focus of markets. Drivers for biologicals can also be developed internally through messaging about future-proofing in preparation for market or regulatory changes.

  There is a market drive internationally to go towards softer pesticides, particularly around insecticides. People do want biological options, but they tend not to work as well and are more expensive; this is always going to be a problem. But if you can develop a programme of control and find a slot for the product, it would be great… It's about finding that window. With other product groups, even if there isn't the urgency, sometimes there is this problem later on, and you have no other options; here is that gap that biologicals can fill. Industry stakeholder interviewee

- **Collaborate with other product groups.** Find or create opportunities to join forces (e.g., co-fund research activities) with other product groups to develop biological solutions that may benefit multiple sectors. Organisations like ALT or agrichemical companies that work with a diverse range of sectors could be a good opportunity. Collaboration can unlock scale, reduce duplication of efforts, and increase access to biological opportunities or research capabilities that might not be possible for smaller product groups.

  We do find that agrichemical companies come around and talk to a wide range of product groups. If you had the agrichemical suppliers come in and pull in the bodies together to have a chat about "we have this product, where can we use this?", maybe they could get it together to do the research. Industry stakeholder interviewee

An *awareness and integration of biologicals checklist* tool has been developed based on the learnings from the case study (see below). It is intended as a practical guide for product groups to assess their product and system readiness and strengthen extension planning for extending biological solutions.

Awareness and integration of biologicals checklist

Part A: Product & System Readiness

1 Assess product fit and system readiness

Before investing in extension, ask: ***Is this biological a good fit for your product group, and is the system around it ready to support growers?***

A. Is the product viable?

Ensure **all** of the following are true:

- ☐ Is effective enough to address a gap or serve as an alternative to a chemical product, and this effectiveness has been demonstrated under New Zealand field conditions over several seasons.
- ☐ Can be integrated into existing grower practices, including ease of handling and application.
- ☐ Is viable economically.
- ☐ Is backed up by published independent research data and respected scientists / institutions.
- ☐ The supply chain is ready to meet the demand of your product group scale, should adoption increase.
- ☐ Its use is within the scope of the label approved by Agricultural Compounds and Veterinary Medicines (ACVM).

B. Is there a compelling value proposition for growers?

At least **one of the following** should be true:

- ☐ Helps growers meet market demand or regulatory pressures.
- ☐ Fills a significant gap in the current crop protection programme (e.g., can address a pest or disease threat).
- ☐ Offers unique advantages over chemical alternatives, such as being able to be used during sensitive crop stages or reducing the environmental impact of the crop.
- ☐ Aligns with your industry's long-term strategy or sustainability goals, which growers support.

C. Is the support system in place?

Success is more likely with more of the following in place.

- ☐ **Key players with influence on growers** (e.g., levy bodies, product groups) **publicly back** the product's use, agree on the key messages, and are happy to communicate the product to growers through their channels. Making sure this support is visible before rolling it out widely.
- ☐ **A coordinating body** is ready to lead / coordinate the extension and champion this product. Ideally, this consists of representatives from all key players in your sector.
- ☐ **Crop protection advisers** have opportunities to get their questions answered, understand how the product works, where it fits, and are confident in communicating with growers about this.
- ☐ There are **researchers or technical leads** who know the R&D behind the product and are willing to support communication efforts, answer questions, or help troubleshoot when needed.
- ☐ There are resources, or at least plans to bring in resources, to **gather and analyse data post-launch** to keep refining how the product is used, understand why it works (or doesn't), and support growers over time.

Awareness and integration of biologicals checklist

Part B: Extension Planning

2 Prepare your core messaging

Once you know the product and system are ready, develop answers to the questions growers are likely to ask. Test these questions and answers with trusted advisors who work directly with growers.

Prepare to answer the following:

- [ ] Why should I use this product? What's the benefit to me?
- [ ] How effective is it, and what's the evidence?
- [ ] What does the product cost? Where can I get it?
- [ ] What's the mode of action? When and how should I apply it?
- [ ] How does it fit into existing chemical / biological rotations to support resistance management?
- [ ] Are there use constraints (e.g. storage, mixing, expiry)?

Ideally, draw on local trial data from your sector's crops to answer these questions. If you don't have this, run some small on-farm trials with early-adopter growers to **generate sector-specific evidence.**

3 Plan your extension activities

Build your delivery plan based on your product group's strengths, resources, and trusted networks.

What in-person opportunities can you run with growers or advisors to talk about this product?

- [ ] Run your own workshops, field days, etc.
- [ ] Partner with research providers or commercial companies to co-host.

Who are your trusted advisors and grower champions (by crop / region)?

- [ ] Identify advisors or growers who can help communicate the product with credibility.
- [ ] Book technical experts or researchers to support these events and answer technical questions.

What support can you give growers who are keen to use this product?

- [ ] Offer guidance to help ensure on-orchard trials are as robust and informative as possible (without being overly scientific or complex), such as process checklists and templates.
- [ ] Providing supporting technologies, such as pest and disease monitoring tools, is advantageous
- [ ] Establish simple ways for growers to collect and share results (or informal learnings) with you.

What materials should be developed?

- [ ] Think about decision support tools, FAQs, or case studies.
- [ ] Ideally, materials should range from summaries to more technical info, depending on the audience. Prioritise easy-to-digest information that is supported by visuals if this is not feasible.
- [ ] In particular, capture the growers' voice, especially in good use examples

What communication channels can you use to spread the word or share resources?

- [ ] Think about newsletters, grower portals, crop manuals, social media, and websites.
- [ ] Don't forget in-person opportunities like workshops, field days, or industry events you're already running or contributing to.

Appendix A: Overview of biologicals for this study

This section expands upon the biologicals explored in the case study, including what enabled their development and commercialisation, an overview of the product and how it works, and the adoption levels of the product.

Aureo Gold for the control of Psa

In 2010, a vine-killing kiwifruit disease *Pseudomonas syringae pv actinidiae* (Psa) was discovered in New Zealand, wreaking havoc on the kiwifruit industry and economy. This air-borne bacterium quickly covered 92% of all kiwifruit-growing regions in New Zealand, causing leaf spotting, shoot die-back, cane and leader die-back, bud browning, red-brown exudate from leaders and trunks, and even plant death.[4] At the time, there were few products available that fully controlled the disease while meeting all the market and consumer standards.

Some common control solutions available at the time of the outbreak to growers included:

- Copper: Reduced leaf spotting by 30 to 50%. However, there were concerns about leaving residue, the environmental impact, and that it cannot be sprayed during flowering, at which point Psa would return.
- Antibiotics: Reduced leaf spotting by around 80%. However, there were heavy restrictions on how antibiotics were applied and used due to concerns about resistance and bee pollination.
- Actigard: Reduced leaf spotting by up to 73%. However, there were concerns about leaving residue, and it cannot be sprayed during flowering.

As such, industry and government pushed for the development of a new product that would better defend against Psa. Researchers discovered what is now known as Aureo Gold in 2013 and began the quickest commercialisation process ever for a biological. Aureo Gold is a natural yeast product that reduces the growth and spread of Psa bacteria and reduces leaf spotting by 30 to 50%. It was subsequently launched into the market in 2018, to great commercial success and widespread praise.

Adoption of the product

Once Aureo Gold was released in 2018, the initial 500kgs of stock sold out within three days, and now it has a growing local and international presence. Conventional growers were the first to adopt the product. Organic growers adopted Aureo Gold later, as at the time organic growers did not have the super spreader to effectively spread the spray solution on the plant.

In 2020 there was an estimated 6% adoption rate for conventional growers and 4.5% for organic growers. Currently, one interviewee reported that there is an estimated 53% adoption rate for conventional growers and 35% for organic growers.

Microbial products for the control of fireblight

Fireblight is a devastating bacterial disease of apple trees in New Zealand and globally, rendering the tree less productive. Fireblight incidence and severity vary year to year and among regions and sub-regions. Most years, there is some degree of fireblight around. A particularly bad fireblight year in the

[4] https://www.plantandfood.com/en-nz/article/new-biological-control-for-kiwifruit-disease

1980s almost destroyed the pear sector. In some overseas territories, fireblight is not present and is a trade barrier for NZ's export apples (e.g., to Australia).

One of the common products used at the time to treat fireblight was streptomycin, which had a synthetic antibiotic as its active ingredient. Concerns around resistance emerged, leading to an interest in biological alternatives as they are advantageous in managing disease resistance compared to conventional products. Moreover, the period of activity of streptomycin is very short (four days), so application timing around flowering is critical. It is less forgiving of timing than biologicals, and very ineffective if that timing is wrong and would be better used along with biologicals rather than as a standalone product.

A few biologicals are available to growers to be used for the control of fireblight:

- Blossom Bless (Grochem) – First registered in 2011, it is manufactured in New Zealand. It requires refrigeration along the supply chain, and work is currently being done to further improve the product.
- Serenade Optimum (Bayer Crop Science) – First registered for fireblight in 2017, it does not require refrigeration along the supply chain and has no known resistance issues.
- Bacstar (UPL Limited) – It does not require refrigeration, but there is a chance of developing resistance from repeated use.
- Clarity (Grochem) – It does not require refrigeration, and it is not a specialist for fireblight.

These products are used in an IPM setting alongside other non-biologicals such as minerals (copper products) and antibiotics (streptomycin-based products), as well as good cultural practices (e.g., flower thinning, leaf litter removal, and removing infected wood). Their use is especially important in younger trees as they establish in the orchard.

Adoption of the product

These biological microbials are used extensively every year. There is no evidence of reticence from growers, who understand the shelf-life limitation. All products have a useful degree of efficacy in the context of biologicals and are used widely in the sector. All products are readily available, although the shelf life of Blossom Bless and its availability may be limited at times compared to Serenade Optimum.

Products for the control of lepidopteran pests

Lepidopteran pests are moths that can infest apples in NZ. They damage the plant and fruit, and more importantly, if they are detected in fruit, there are restrictions to some markets. Particular markets have a zero tolerance to codling moth, primarily the East Asian markets of Japan and Taiwan, where premium prices are paid. Growers wanting to access the high-value East Asian markets must comply with the zero-tolerance limits, and this is monitored by MPI within the official Codling Moth Sensitive Market programme. With New Zealand Apples & Pears (NZAPI) focusing on market access, the intent is to have zero codling moth in packed fruit before they leave NZ. This requires a multi-pronged approach to control, using a variety of products: selective chemistry, natural enemies, pheromone-based mating disruption, and bacterial and viral bio controls.

Biologicals for Lepidopteran pests were borne out of the sector-wide shift from non-selective pesticides in the 1990s. Prior to this, inspections of export cartons in NZ destined for the US market revealed a 15-20% failure rate. After the transition to selective insecticides, the failure rate reduced considerably

to < 5%. Since then, NZ's focus on export markets has shifted more towards Asia, and some growers have exited the USA market. Due to this, the market is considered mature in the use and understanding of biologicals. Products used include:

- **Pheromones as biocontrols –** the market is dominated by two key suppliers, NoMate (Grochem) and Isomate mating disruption products. Individual pheromones are very specific to the target pest, so some multi-target products have multiple pheromones incorporated.
- **Bacillus thuringiensis ('Bt') products –** the Bt products on the market control a multitude of lepidopteran pests but are less effective against codling moth, unlike chemical products. Bt products persist for only a few days, so timing is important.
- **Nuclear polyhedroviruses ('NPVs' / baculoviruses)** – these products are the natural virus of the target pest; each virus is specific to one pest. NPVs are used less than Bt products and are not pushed as much as the other types of products.

Adoption of the product

Pheromone products are the most used of the above biologicals for the control of lepidopteran pests, with an estimated 30% of growers using them. They are used as an insurance policy to ensure market access is achieved through low pest numbers. Use of Bt is increasingly common. However, as many of these products are mature in the market, no new resources are going into their improvement or extension, and no detailed monitoring data is collected on the use of the products. As such, adoption has been static over the last 10 years.

Products for the control of mealybugs

Mealybugs spread a devastating virus disease that impacts the yield and quality of grapes, and their honeydew can cause sooty mould infestations on fruit, potentially ruling out grapes from processing. However, despite the economic driver and prevalence of mealybugs, two biologicals released in recent years for mealybug control have had very little impact. The product options are:

- **Grandevo** (Nufarm) – a microbial product, but the organism is inviable, and some unknown components of the fermentation solids mediate its effect.
- **Desire Mealybug** (UPL limited) – A dual-pheromone lure used primarily as a monitoring tool, which, when used in a delta trap with a sticky base, attracts the adult male mealybugs of the two dominant species in vineyards.

Adoption of the product

Both Grandevo and Desire Mealybug are recently developed biologicals which are not widely used. Grandevo is only used by some organic growers and is expensive.

Appendix B: The extension system

This section expands upon the extension systems within which the biologicals explored in this study are utilised, specifically in the kiwifruit, apple, and winegrape sectors. We explore the commonalities and differences between these sectors in market focus, sector structure, and industry branding / culture.

Overview

All three sectors examined in this case study broadly align with the influence pathway described in Figure 2, with some differences in the strength of influence between certain bodies and the different organisations within each sector. The diagram is intended as a starting point for understanding the dynamics of extension systems across different crop sectors

For the case study

The differences and similarities of the extension systems between the kiwifruit, apple, and winegrape sectors, specifically in relation to market focus and sector structure, are explored further below.

Market focus

Key influences within a sector in extension may stem from a differing market focus. For example, the kiwifruit industry is New Zealand's largest fresh horticultural industry by exports, and in comparison, has significantly more resources to be invested in extension with dedicated extension practitioners to make sure growers are supported and production is up to standard. Its crop protection standards are shaped by global standards and international market requirements (e.g., Good Agriculture Practices certification system). Among these, the strong demand from Asian markets, such as China, Japan, and South Korea, also has a significant influence on production practices and messaging delivered to growers.

The apple sector, on the other hand, primarily followed EU market standards, which are generally regarded as the highest of any market, although more recently, New Zealand exports have swung towards Asian markets, lessening the pressure to abide by those higher standards. However, as previously mentioned, with the government-mandated programme controls and monitoring of codling moth, and a key focus on export by NZAPI, the apple sector has been a leader in the use of biologicals. A range of products has been introduced over the last 30 years, and have culminated in an admirable integrated pest management system available to all growers.

In the winegrape sector, a key influence is the Sustainable Winegrowing New Zealand certification programme (SWNZ) led by New Zealand Winegrowers (NZW). SWNZ was launched in 1995 and has since attracted the vast majority of wine growers and wineries across the country. Today, it's reported that 98% of New Zealand's vineyard producing area is SWNZ certified, and over 90% of the wine produced in New Zealand is processed in SWNZ-certified facilities[5]. The certification allows growers to make sustainability claims on their wine labels, aligning with international market expectations. This system plays a key role in meeting market demands and has a great influence on growers' decision-making, including the use of crop protection products. The certification process requires the submission of a full spray diary annually, which documents all agrichemical applications made to the vineyard that season. Moreover, unlike fresh fruits such as kiwifruit and apples, winegrape are processed

[5] https://www.nzwine.com/en/sustainability/swnz/

domestically into wine (less perishable) and then exported, which adds a different market dynamic to the sector compared to others.

Sector structure

Interviewees highlighted that the differing roles of the sector bodies between the three sectors can have a significant impact on extension. For instance, the kiwifruit sector structure is highly centralised with Zespri acting as a single desk marketer who also has a strong presence in research, development, and extension. To sell / export kiwifruit from New Zealand, all growers and post-harvest organisations must have some contact with Zespri and follow their standards and ensure products meet regulatory requirements. They provide a list of recommended crop protection products that growers must use to be able to sell. Additionally, Kiwifruit Vine Health, which was established in 2010 for Psa but has since broadened to managing all biosecurity issues within the kiwifruit industry, also has a strong presence in the extension field. Together, Zespri and KVH are responsible for the majority of the extension activities for kiwifruit growers, including field trials, workshops, training programmes, and resources such as tools and guides.

On the other hand, the apple sector body, NZAPI, does not trade in fruit or its products, unlike Zespri. However, it remains central to the flow of independent information on biologicals, but less prescriptive than in the kiwifruit sector on exactly what products growers should use. But similar to Zespri, the sector body plays a key role in generating field data on biologicals and extension in general, with a research and development committee dedicated to this, which may be a flow-on effect from being a single desk exporter in the early 2000s. Communications to growers are driven through NZAPI's Agrichemical Advisory Group, with representatives from across the value chain, including key technical champions in research and retail organisations (e.g., PFR and FruitFed Technical) who have a trusted, long-standing local presence. Their extension activities include yearly research review workshops, detailed research reports, and face-to-face meetings and field days with growers across the country.

For winegrape, NZW is the sector body; unlike the other two sectors, there is a sense of more independence between different actors in the value chain compared to kiwifruit and apples, leading to more varied messages on biologicals. Additionally, there has also been less history in the use of biologicals. As such, much more persuasion backed by commercial evidence is needed in the winegrape sector to encourage the adoption of biologicals. The sector also has an in-house research institute, Bragato, that drives the majority of research and development and contributes to extension.