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Softer Crop Protection, The Way of The Future?

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I wish to thank the Kellogg Programme Investing Partners for their continued support.

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Table of Contents

List of Figures

List of Tables

1. Executive Summary

This report addresses the incorporation of biopesticides and integrated pest management (IPM) strategies into the horticultural sector in New Zealand. A combination of a literature review and semi-structured interviews were undertaken and analysed using PESTLE analysis.

The New Zealand horticultural sector is diverse and export-focused. Each crop sector has different crop strategies to control pests and diseases to meet export market requirements. Globally, consumers are more connected to the source of their food with each market focusing on different components. This is complex for growers to meet most market demands. Biopesticides and IPM is investigated to determine if these are viable options for crop protection.

The final recommendations were split into *People* and *Mechanics*.

People

People do not like change which is a large barrier to the use of biopesticides and IPM. Change often occurs when market requirements are altered or in a 'crisis'. Many growers have been misinformed on IPM or biopesticides before putting them into practise, which can result in a false sense of perception and a lack of trust. This results in many not willing to try again and spreading misinformation. Biopesticides are often more expensive with less efficacy than synthetic chemicals. There is little incentive for growers to change with no perceived economic value.

IPM is more welcomed within the industry. Knowledge was also identified as a barrier. There is more motivation toward this approach as there is a perceived view that there may be less chemical costs.

Knowledge domestically is lacking in IPM and biopesticides. Key experts in these fields must be identified. Clear messaging is important. Experts must collaborate to produce a strategic approach to build a network of knowledgeable and trustworthy industry leaders. The use of international tools and other experts should be seriously considered to reduce costs and accelerate learning. Science-based decisions on crop protection are important to set growers expectations to reduce mistrust. Growers will need considerable support and industry must be ready to provide this.

Currently, there is no formal training for people who provide agronomic advice to growers. These people hold a large influence. Agricultural retailers and agronomists should collaborate and set a formal standard incorporating the entire 'toolbox' to build consistency within this sector and build confidence in growers.

NZ growers need to be adaptive to obtain market access with more markets aligning with a whole farm holistic approach. Ethical, sustainability and low residues in food are likely to trend with markets. IPM and biopesticides fit well for this market.

Chemical resistance management was one of the largest concerns. There is high reliance on chemicals and different controls should be integrated to build adaptability. The need to educate the entire industry is critical to protecting the current chemical controls. Slow regulatory agencies have a negative compounding effect on chemical resistance.

Mechanics

Regulatory agencies are a considerable barrier to crop protection. The current cost recovery strategy is low and ecotox models are outdated. Increasing the cost recovery for new products to enter New Zealand per application is advised to enable more funds to be utilised to upgrade internal risk assessment tools such as the ecotox models. Participants in this study were open to this recommendation if the timeframes were quicker and more reliable. This hinders both chemical and biopesticides entry to the New Zealand market.

Technology was a key tool identified to compliment IPM and biopesticides. The use of technology to predict pest pressure will enable growers to make informed decisions. These tools can also justify crop protection decisions to export markets. Research farms with demonstration abilities can help growers make crop protection decisions when they are particularly risk-averse before investing. They also ensure methods can be implemented practically before reaching growers.

Implementation of biopesticides and IPM will not be easy with the largest hurdles being the knowledge gap and the regulation of products. As an industry, it is important to move toward these approaches to maintain a strong future market share.

Abbreviations

ACVM- Agricultural Compounds and Veterinary Medicines
EPA- Environmental Protection Authority
EU- European Union
FAR- Foundation for Arable Research
IPM – Integrated pest management
KTA – Knowledge to Action
MRL- Maximum residue limit
NZ- New Zealand
TPP- Tomato Potato Psyllid
UK- United Kingdom
VICE- Vegetable Industry Centre of Excellence

Definitions

Biopesticide is a pesticide that derives from natural materials such as plants, animals, bacteria, or minerals.
IPM (Integrated Pest Management) is a strategy that combines methods to manage pests and disease while reducing risks to health and the environment. This encompassed biological, physical, cultural and chemical controls.
'Snake Oil' is a product or system of little real worth or value that is promoted as the solution to a problem.
'Toolbox' encompasses all crop protection strategies to control pests and diseases.

2. Aims and Objectives

This study aims to understand the role that biopesticides and IPM have in the current NZ horticultural sector. The objective of this research is to determine the level of uptake within the NZ market and if there are any barriers to further integration. A conclusion and recommendations will be the outcome of this study as a pathway for the industry.

3. Literature Review

3.1 Introduction

This literature review will discuss the NZ horticultural sector, focusing on crop protection strategies. The investigation of biopesticides and IPM is undertaken to see the scope of these two methods in the horticultural sector. This review will also encompass factors that may influence the integration of these two methods.

3.2 New Zealand horticultural market

NZ is an isolated subtropical country that grows a diverse range of vegetables and fruits. Horticulture is the third-largest exporter within farming which produced $2.81 billion worth of domestic horticultural produce and $4.67 billion ($3.94bn fruit, $0.73bn vegetables) value which was exported in 2023/24 (Horticulture New Zealand, 2024; Ministry of Primary Industries, 2024). NZ is an exporting nation and geopolitics can have a large impact on this sector.

Geopolitics is increasingly more volatile at a fast pace and can impact our economy. Due to the high export revenue, NZ has a strong focus on aligning with export market requirements. Each country has different constraints and NZ must be adaptive. For example, China has a high focus on food safety, while the EU has a strong focus on agrichemical use and residues in food (Djekic et al., 2023; Dong & Jensen, 2007). The EU has set ambitious targets under the 'Farm to Fork' strategy to reduce pesticide use by 50% by 2030 (Djekic et al., 2023). This strategy aligns closely with modern consumers demands (Djekic et al., 2023). Global Gap is an independent voluntary system used as a quality assurance and food safety tool (Wysokiński et al., 2012). In the 2024 Horticulture report it stated there were 4500 growers in NZ, 3700 have either NZGAP (NZ tailored), Global Gap (International standard) or both (Horticulture New Zealand, 2024). Although not compulsory, globally this system builds transparency to markets and consumers. Crop pests and diseases must be managed appropriately to meet market requirements. Agrichemicals are a tool commonly used to control pests and diseases. Often agrichemicals can increase yields and furthermore profits (Liu & Qiu, 2024; Tai et al., 2025). MRLs must be managed through careful crop protection planning. More recently consumers are becoming more interested in the way food is produced (Boca, 2021).

NZ has levy organisations broken into crop sectors. Levy payers vote on the focus of the levy organisation which is often research and development, quality assurance and market access

(Narayan & Rutherford, 2012). The government will also allocate funds to levy organisations. There is a considerable number of levy organisations in horticulture due to the diverse crops grown. A limitation of this structure is that smaller levies will spend a relatively large proportion of funds on administration fees (Narayan & Rutherford, 2012). These groups are important knowledge-sharing networks with a specific strategic focus.

3.3 Biological and IPM crop protection

Synthetic agrichemicals has been the backbone of agriculture crop protection. Market shifts to a 'softer approach' has resulted in IPM and biopesticides gaining industry interest. IPM and agroecological pest management have become more researched since 2021 (Figure 1). Some growers are sceptical due to limited education when integrating them historically (Guo et al., 2021). High costs of biopesticides are also a barrier to adoption (Guo et al., 2021). Table 1 demonstrates that 'Eco-BB' a biopesticide costs $226.44/ha which is considerably more than Bandit 350 SC $46.80/ha.

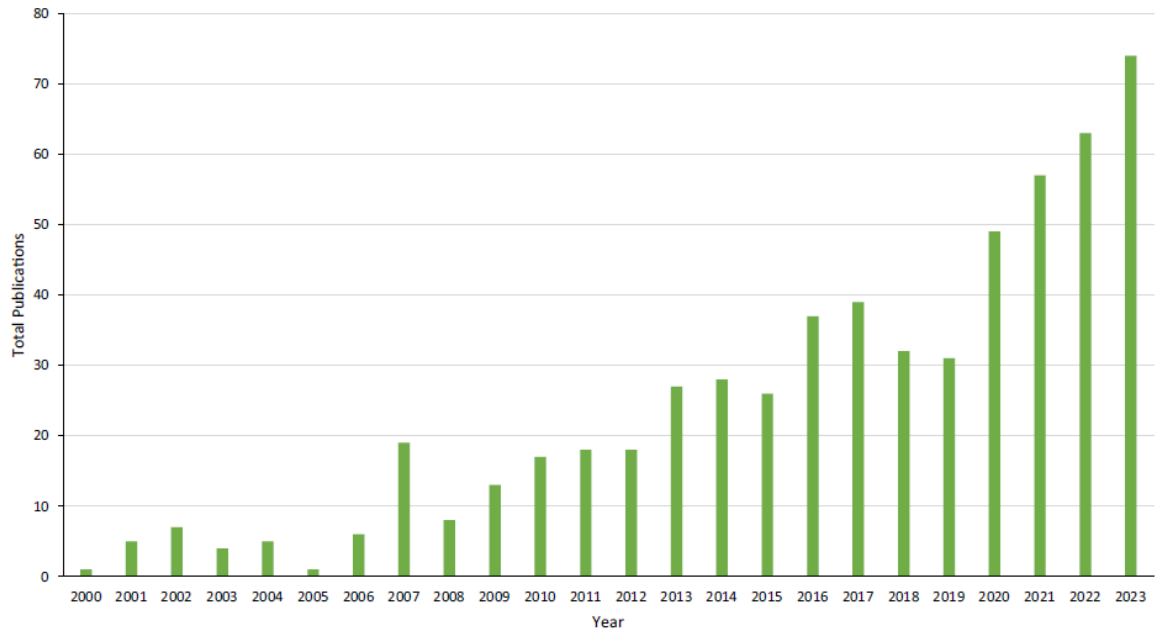

Figure 1: Annual publication output globally on biopesticides in the fruit crop protection sector (Ikhwani et al., 2024)

Table 1: Application rates and cost of biopesticides and synthetic insecticides in South Africa over a season based on ten sprays (Malinga & Laing, 2023)

Trade Name	Active Ingredient	Type of Pesticide	Rate per hectare	Total cost/ha-10 applications (USD)
Eco-Bb	Beauveria bassiana	Biopesticide	300 g/ha	$226.44
Bolldex	Nucleopolyhedrovirus	Biopesticide	200 mL/ha	$495.74
Delfin	Bacillus thuringiensis	Biopesticide	1 kg/ha	$602.32
Karate EC	Lambda-cyhalothrin	Synthetic	120 ml/ha	$58.87
Chlorpyrifos 480 EC	Chlorpyrifos	Synthetic	200 ml/ha	$27.93
Bandit 350 SC	Imidacloprid	Synthetic	200 ml/ha	$46.80

Biological crop protection is not a new concept which enables natural predators or microorganisms to colonise the crop to control pests and diseases (Ferron & Deguine, 2009). IPM has at least 21 definitions with most incorporating biological, cultural and chemical controls (Horne et al., 2008). IPM is often referred to as a 'toolbox' approach with many options utilised toward crop protection. A larger and diverse 'toolbox' enables growers choices. Apple and Pear NZ will be discussed as a successful example.

Apples and Pears were introduced to NZ in 1819 however, the normal beneficial insects were not present (Wearing, 2019). In the 19th century, pests started to reduce the production and quality of fruit and the use of pesticides soon followed (Walker, 2017). Chemical resistance occurred from overuse and more chemicals were applied to achieve control. In 1962, the IPM implementation started and around this time beneficial insects were introduced (Walker, 2017). Pheromone traps for some insects were used as a tool to determine if organophosphate sprays were necessary. Investment in IPM was occurring but growers education was lacking. Figure 2 highlights the knowledge sharing system and diversity among the industry involvement to build IPM in the Nelson region. A strong focus was made on orchard advisors due to the high level of influence they had. Once confidence was built within this region, this was rolled out nationally and Nelson was a case study to build national confidence. This industry is world-leading in IPM and was highly successful with full industry engagement.

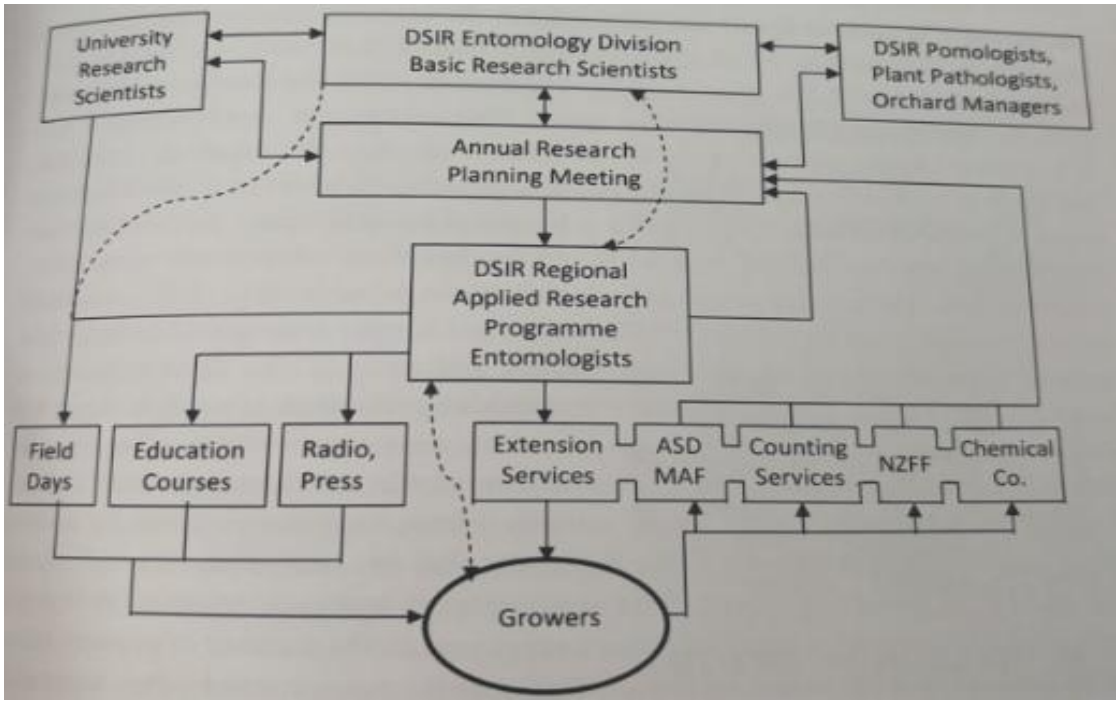

Figure 2: Organizational structure behind the IPM program for Pipfruit NZ (Wearing, 2019)

The following study showcases the use of an oil application to reduce synthetic chemical use. MacDonald et al. (2022) highlighted that 14-16 insecticides are commonly applied to a potato crop per season in the Waikato to achieve insect pest control. This study over three years found that insecticide applications could be reduced by utilising crop scouting, insect trapping, modelling tools and utilising JMS Oil (isoparaffinic petroleum distilled oil) as a substitute for some insecticide sprays. During one year, scouting and sticky traps delayed chemical controls by 4 weeks. This study concluded on average 50% less insecticide applications could occur when these methods were incorporated with no yield or quality deductions. This study was an industry collaboration with Plant and Food Research and A.S Wilcox.

Both studies previously discussed demonstrate a wider 'toolbox' can be used to control pests effectively. The use of technology such as insect modelling and tools is highlighted to compliment IPM and growers decision making. Current crop protection strategies will be discussed in the next section.

3.4 Current crop protection strategies

Many agricultural systems rely on synthetic pesticides to increase quality and yield. Longo and York (2008) concluded that there is a positive relationship between agricultural exports with fertiliser and pesticide use. Figure 3 illustrates the increase of pesticides over time, with a

positive relationship with pesticide use with an increasing population and food demands (Hedlund et al., 2020).

NZ has limited published records of the pesticide volume and types used domestically. Figure 3 illustrates from 2005 to 2008, there was a consistent increase in pesticide use in NZ, similar to global trends. A lack of pesticide information domestically poses a risk of unknown pesticide use patterns. The use of the same chemical applied multiple times to a crop increases the risk of resistance (Van Toor et al., 2013). An example is in Marlborough, with an increase in some ryegrass resistance to glyphosate under grape vines as this was a common annual practice (Buddenhagen et al., 2020). Another study concluded there is resistance to three modes of action in the control of *Stemphylium* in onions (A Lighter Touch, 2025). These studies highlight that resistance results in fewer options within growers 'toolboxes'.

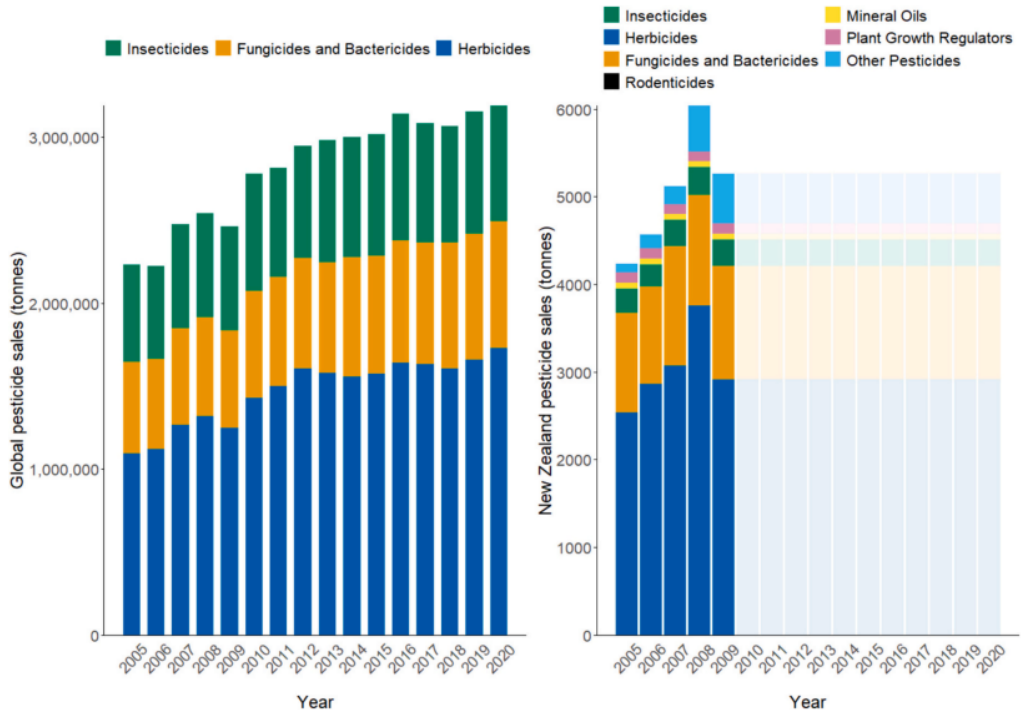

Figure 3: The global (left) and New Zealand (right) pesticide sales from 2005 to 2020 (Tai et al., 2025)

Globally, there is pressure to produce food more sustainably, which is reflected in regulations (Finger et al., 2024).The EU aim to reduce pesticide risk and use by 50% by 2030 (Finger et al., 2024). Each country has differing MRL limits, which highlights that each country has different measures of 'food safety'. NZ must meet all requirements to obtain optimal market access to achieve international long-term market goals, such as the EU's.

The next section will discuss behaviour change on farm with a focus on crop protection.

3.5 Behaviour change

Literature findings conclude that growers are reluctant to change generally speaking (Nordström Källström et al., 2025). Change occurs in multiple steps starting with affective to cognitive to behavioural changes (Mankad, 2016). Horne et al. (2008) highlights that support to growers is essential to the success of a new strategy. Few experts, strong focus on research rather than implementation, too complex, no local advisors, not enough information or chemical controls that still work are key roadblocks highlighted to IPM adoption (Horne et al., 2008).

The KTA gap can be a limiting factor to integrating research to a farm level. Nordström Källström et al. (2025) supports Horne et al. (2008) findings that if IPM or biopesticides are implemented without a focus on practicality, it poses the risk to fail. Generally speaking, agricultural knowledge is split into three categories however does not follow a traditional linear flow from the 'producers' to the 'users' (Figure 4). Nordström Källström et al. (2025) concludes that growers trust growers and can be highly influenced at this level. Research suggests that this collaborative approach results in generating crop protection strategies that are practical at the farmer level with wider adoption (Figure 5).

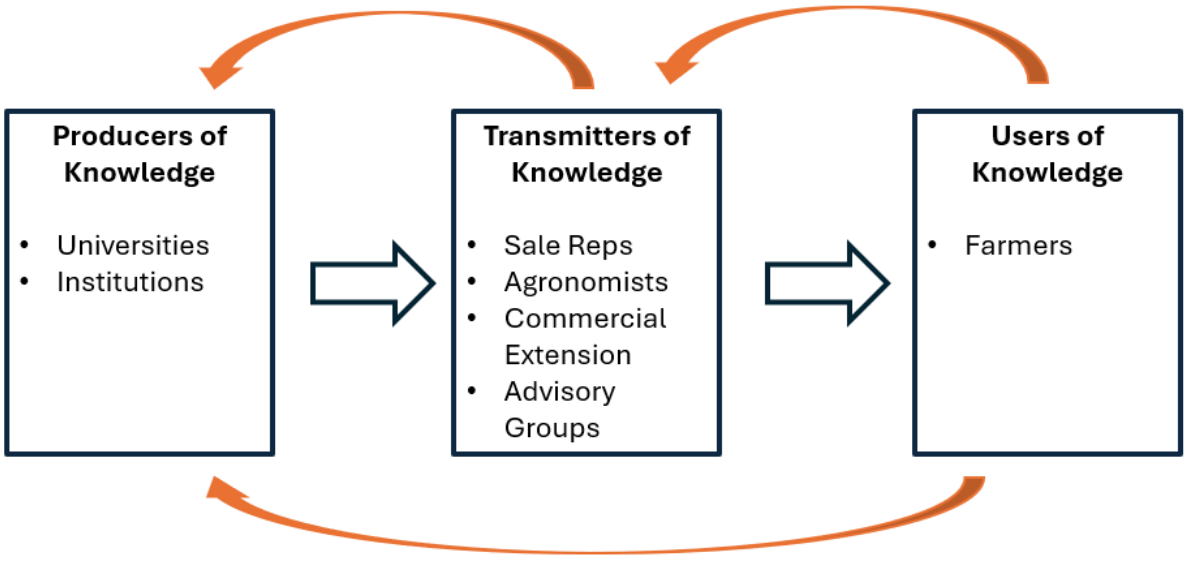

Figure 4: The three groups of knowledge sharing in agriculture based on the 'Agricultural Knowledge and Information System'. The orange arrows indicate a collaborative and network approach. Information sourced from Nordström Källström et al. (2025) however the diagram was made specifically for this report

An example was in the Netherlands in the 1960s, with a desire to reduce environmental impacts through a reduction in fertiliser use (Frouws & Van Tatenhove, 1993). Research and tools were developed however, implementation did not occur at the desired rate. 'Transmitters of Knowledge' (Figure 4), were not in support, which resulted in farmers to not implement this strategy. Further discussions from government and environmental institutions ('Producers of Knowledge') with the 'Transmitters of Knowledge' resulted in consistent messaging and implementation.

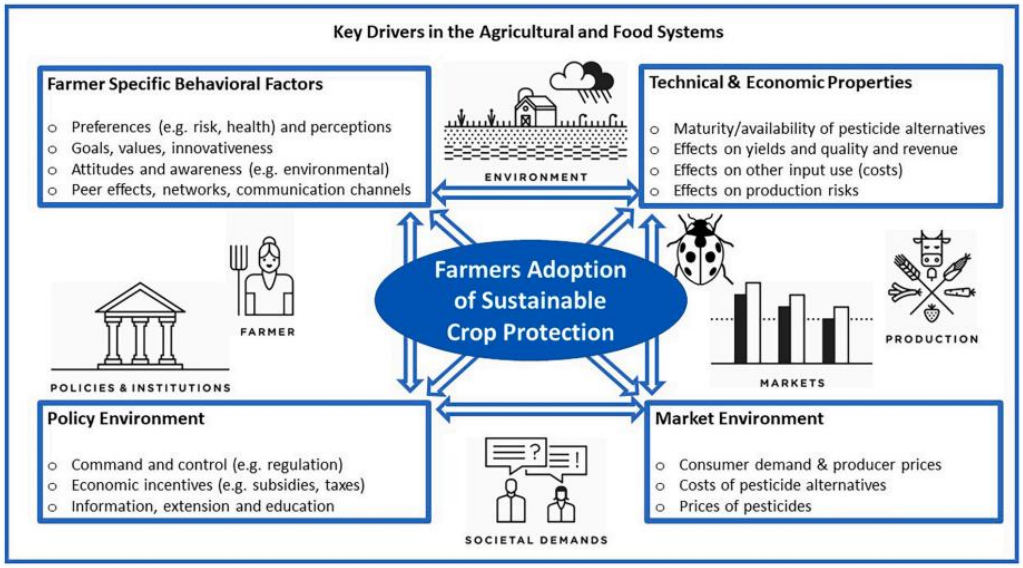

Figure 5: Framework on growers adoption of sustainable crop protection approaches (Finger et al., 2024)

3.6 Current regulations

NZ has strict regulations of the entry of new molecules into the country. Compared to some other countries, this is complex and a slow process for product approval (Ministry for Regulation, 2025). Two regulatory Acts used throughout this process are the Agricultural Compounds and Veterinary Medicines (ACVM) and the Hazardous Substances and New Organisms (HSNO). Ministry for Primary Industries (MPI) and the Ministry for the Environment (MfE) administer these which are regulated by NZ Food Safety (NZFS) and the Environmental Protection Authority (EPA) regulate these (Ministry for Regulation, 2025). NZFS focuses on the evaluation based on efficacy data benefits and risks while EPA assesses risks to the environment and human health (Ministry for Regulation, 2025). Figure 6 illustrates how NZFS and EPA work alongside each other (Ministry for Regulation, 2025). Statutory timeframes are set however rarely achieved. Between 2013 and 2015, on average 110 decisions were made while between 2021 and 2023, 82 occurred (Loan, 2023). Limited funds and assessors globally are two challenges stated by Loan (2023).

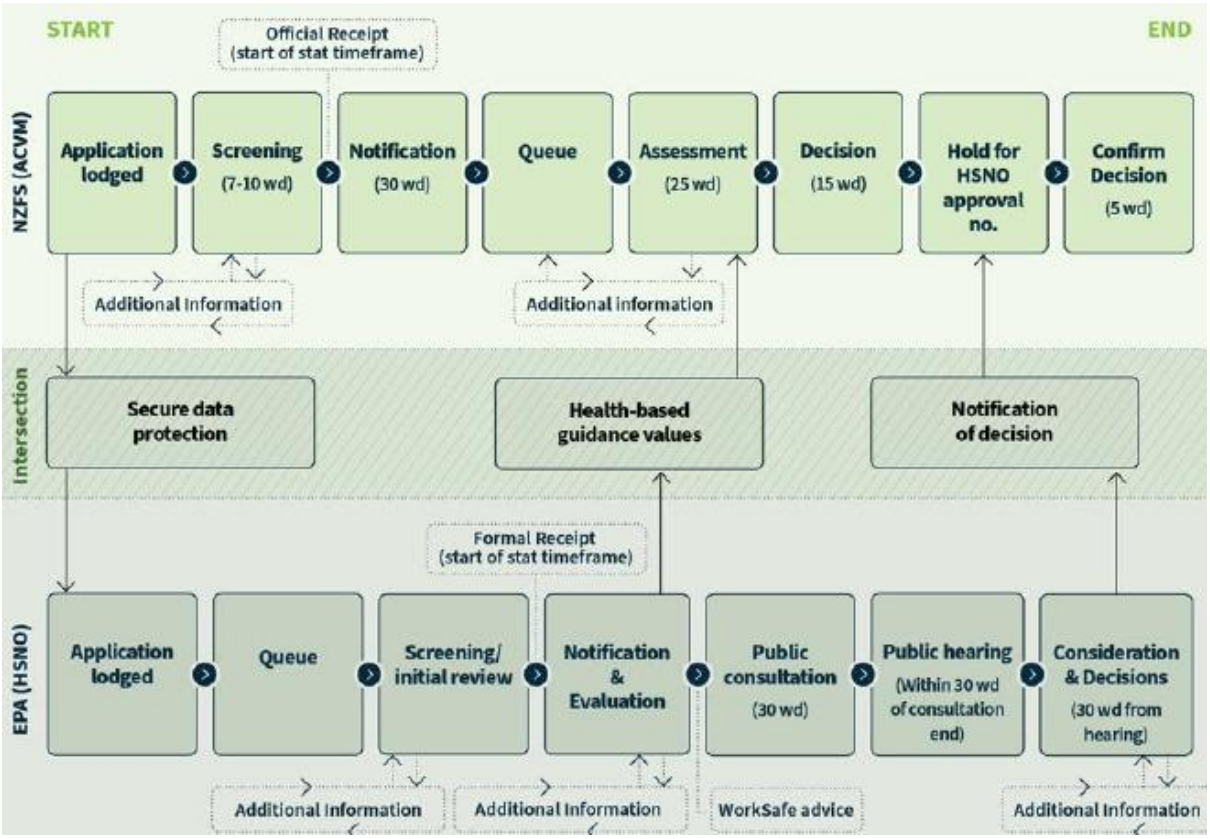

Figure 6: Flow diagram of products requiring both an HSNO and ACVM registration (Ministry for Regulation, 2025)

The EPA is currently under review and in the media for being a difficult and slow process. A delay in new molecules to the market with some older molecules no longer available can increase chemical resistance and a limited 'toolbox'. On average it costed $460 million (NZD) in 2014-2019 to establish a new product (Ministry for Regulation, 2025). This is a considerable investment by companies before obtaining any return on investment (Ministry for Regulation, 2025). The ecotox models are used to predict the environmental concentrations that the chemical may have with four of these models being over 20 years old (Loan, 2023). These outdated models internationally have been upgraded in many countries. Some models are also not tailored to NZ flora and fauna or farming systems and cannot effectively determine risk which can results in an *ad hoc* approach. This poses a risk to the NZ environment if products are not evaluated accurately.

Under the HSNO Act there is low application fees set. For example, in the last five financial years the EPA spent $15.4m on hazardous substance assessments (including reassessments) and only received a revenue of $2.5m through these assessment fees (Loan, 2023). Table 2 highlights that agencies in the USA and Australia obtain over 80% cost

recoverability, while NZ obtains only 14% (Table 2). NZ has fewer applications or complex assessments than Australia or the USA agencies however the proportionate funding is less (Table 2). Loan (2023) concluded that the volume of applications received severely strains the funding. This is reflected in low throughput in this system and few new molecules available on the NZ market. Possibly safer and more sustainable synthetic chemicals and biopesticides may have a delayed entry into NZ, which may increase environmental harm and also increase chemical resistance for current products utilized in NZ.

Table 2: Comparisons of the EPA (NZ) with international regulators with the expenditure per assessment (NZD), FTE (full-time equivalent) assessors, annual applications and the number of completed complex assessments the proportion of cost recovery during the 2021/22 year (Loan, 2023)

Regulator	EPA (NZ)*	APVMA*	EPA (USA)*
Estimated direct expenditure on hazardous substances assessments (NZD)	$3.0m	$21.1m	$56.1m
FTEs working on processing & assessing hazardous substances	32	89	134
Number of applications per year	123	309	-
Number of complex assessments (new active ingredients)	6 (2022 calendar year)	15	35
Proportion of assessment costs recovered from industry	14%	89%	85%

*EPA (NZ) – Environmental Protection Agency, APVMA - Australian Pesticide and Veterinary Medicines Authority, EPA (USA) - Environmental Protection Authority (United States) – Insecticides, Fungicides, Rodenticides Act

Legislation can be a tool utilised to reduce pesticide use, some examples will be discussed. United States legislation, 'IPM Initiative' had a target to have 75% of cropping land operating under IPM by 2000 (Ehler, 2005). An evaluation in 2001 concluded an increase in pesticide use occurred during this time. This legislation failed due to a poor roadmap, a vague definition of IPM and little emphasis on monitoring crops. In 2015 China introduced "Zero-Growth Action Plan for Pesticide Use by 2020" not to reduce pesticide use but rather pesticide use to not increase (Hu, 2024). Although there was a reduction in pesticide use in 2021 compared to 2015 there is concerns less pesticide use may increase costs to growers with additional labour requirements to control pests and weeds (Hu, 2024). The EU's roll out of 'Farm to Fork' strategy has 'non-legally binding' targets of 50% reduction in chemical pesticide use and 50% reduction of use of hazardous pesticides by 2030. In 2024 the European Commission released data that there was a 46% overall reduction use in chemical pesticides and 25% reduction of hazardous pesticides between 2018 and 2022. Legislation can lead to a reduction in pesticide

use however these policies had little focus on biopesticides and rather a IPM focus. Clear messaging and a roadmap is critical to the success of policy.

3.7 Conclusion

Crop protection strategies and decisions are complex and differ for each farm system and crop. Historically, synthetic pesticides have been the main crop protection strategy in NZ. NZ horticulture relies on exporting most of its goods. Adaptation and versatility are key to obtaining and maintaining market access for fruit and vegetables. Globally, there is a lot of pressure to be more sustainable and environmentally conscious. The use of biopesticides and IPM could be a tool used further in the horticultural sector to achieve this.

4. Methodology

A literature review and semi-structured interviews were undertaken to determine the current knowledge within the NZ horticultural sector on IPM and biopesticide integration.

4.1 Literature review

The literature review objective is to provide a context of biopesticides and IPM within the global and NZ context. The information obtained was used to make conclusions and recommendations.

4.2 Semi-structured interviews

Interviews were conducted in person, over the phone and on Microsoft Teams. A set of interview questions were asked to each participant (Appendix 12.1). Questions were categorised. Additional questions were asked depending on the participant's knowledge. All interviews were recorded, and participants signed a Kellogg Rural Leadership Interviewee Consent Form prior to the interview taking place. All interviews were kept anonymous. Microsoft Word transcribed the interviews into text and Google NotebookLM was used to find common themes between transcripts.

Nineteen interviews were conducted. The people interviewed were categorised into the following groups; growers, levy organisations, agrichemical companies, regulatory agencies, biological and IPM specialists and end markets primarily within the horticultural sector (Figure 7). It is highlighted that many of the participants had a broad range of knowledge and provided extensive knowledge outside their selected category.

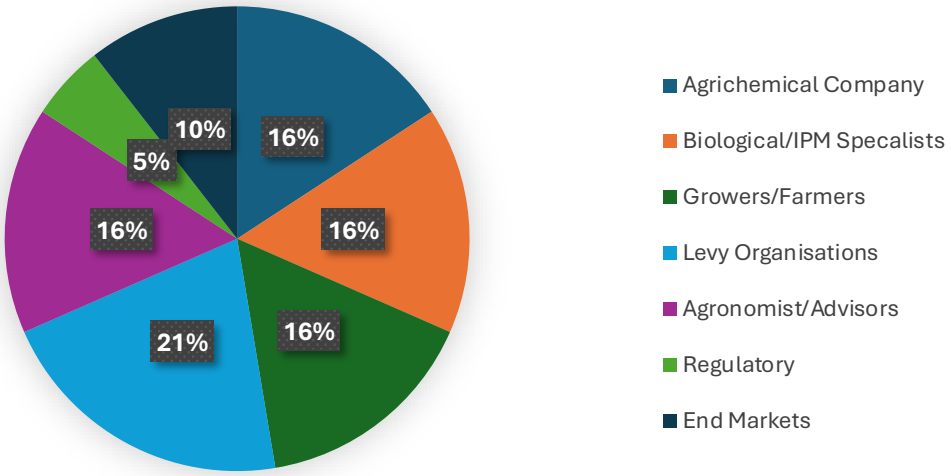

Figure 7: Summary of interview participants by groups

4.3 Imagery and analysis

Miro was used to produce images. PESTLE analysis was used to identify weaknesses and threats in the IPM and biopesticide integration discovered from the interviews. A scale was made from 'Low' importance to 'Very High' importance for each topic addressed.

5. Results and Findings

The interviews were from a wide range of stakeholders (Figure 7). The results are separated into PESTLE sections and assessed on a scale of importance (Figure 8). In this section, key topics will be discussed with the aid of quotes from the interviews.

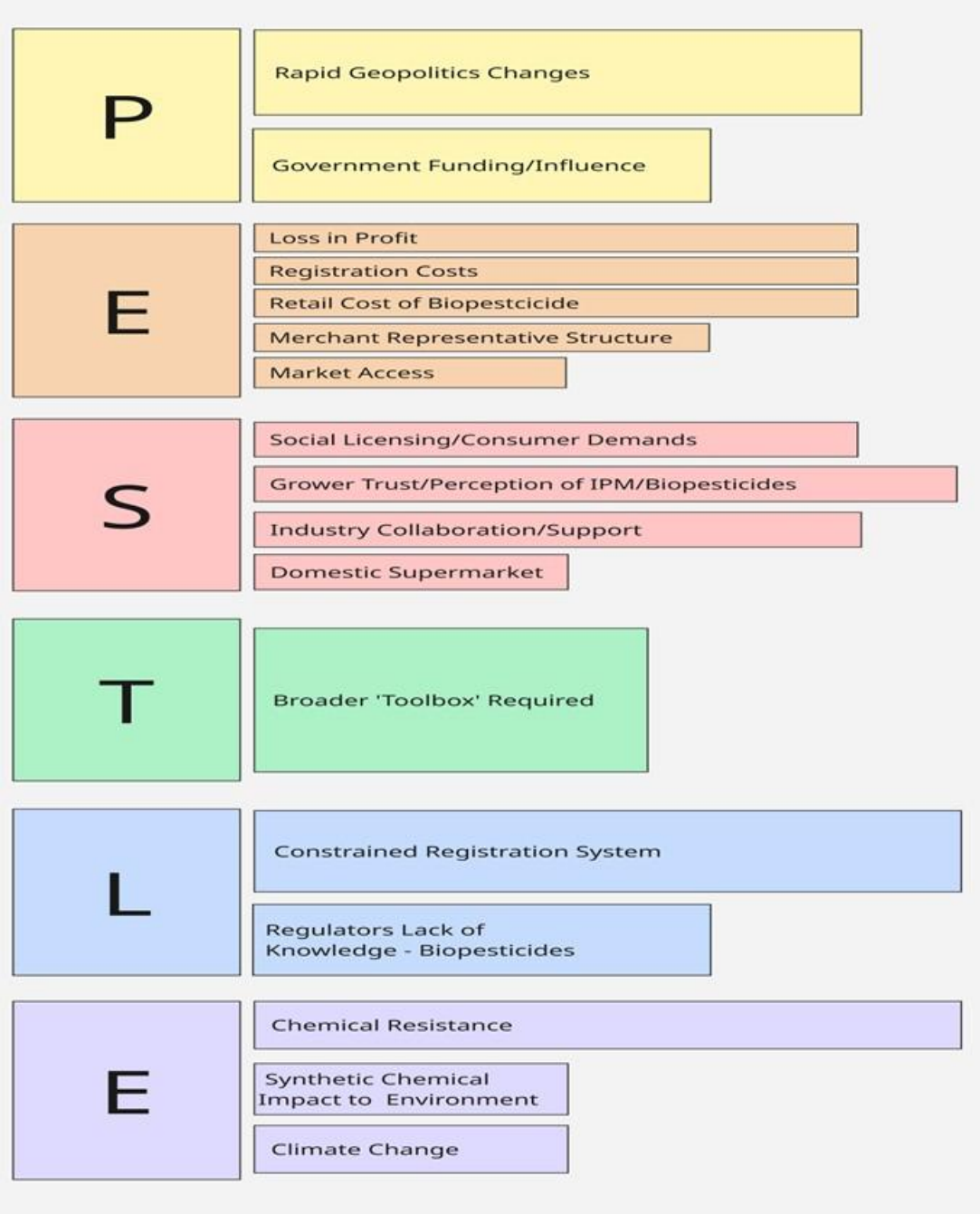

Figure 8: PESTLE diagram of key themes discussed in the interviews. The column lengths represent each topic grade on a scale from 'Low' to 'Very High risk

5.1 Political

Geopolitics is rapidly changing – High

It was clear that all interviewees viewed geopolitics to have a strong impact on the horticultural sector. The export market was discussed much more in-depth than the domestic market. This is due to considerably more revenue generated from exports and is more volatile. During most interviews, the relationship between China and the USA was discussed as a concern for NZ exports. This relationship example is unfortunately not unique with many other countries or leaders to have polarising relationships which can impact trade.

Concerns were expressed about the WTO weakening and a 'shake-up' of the trade environment and trade agreements. Some felt these two trading levers weakening may alter historic trade access. It was highlighted that it could have a considerable impact on our economy. One participant expressed that there will always be challenges with exporting, but with political interference, this can be exacerbated. However, this same participant also saw the silver lining in which new opportunities may arise. For example, the interviewee referred to the weakening relationship between Canada and the USA as an opportunity for NZ to supply to Canada. Many participants thought that globally, NZ is perceived as 'clean and green' and a trustworthy country. This is highlighted as a strong branding strategy.

> *"Exporting will always be challenging… It depends when the political interference comes into it, with the state things are at the moment with Trump throwing curve balls left, right, and centre, if tariffs come in and the WTO has been weakened over the last ten years"*

The sheer speed of change was also expressed as a risk by multiple people interviewed. Some participants feared NZ would be left behind in the global trade world if new crop protection strategies were not available and adopted. Tariff introductions to markets such as the USA were discussed in many interviews as a key example of how change can occur at a rapid pace. Regulations on MRLs or ethical standards were also discussed in depth which have a direct impact on crop protection. Many participants agreed that growers must think of a whole farm system to align with some of these regulations which may be imposed in the future. The key challenge with these changes is that there isn't always enough lead time for growers to change management practices to align with these markets.

Participants felt that most crop protection changes occurs when export requirements shift. Further discussions concluded that growers will not change unless there are economic

consequences. One participant highlighted that Europe as a large trading group, can be stringent around its import requirements for the goods they accept. Some participants thought that biopesticides with low residues may be a good fit for this market.

> *"I think Europe will lead the charge (ethical production). They are diving into this space already, and they can be more picky with what they source just because of the number of countries and the trade relationships that they have…"*

Most felt growers are heavily reliant on chemical controls; this poses a risk that growers may not be adaptable to access regular markets if the regulations change in agrichemical use. One participant believes the crop protection 'toolbox' growers have is outdated, and NZ may not be able to cope with the future trade requirements.

> "*Our biggest issue is that anytime tomorrow given the geopolitical landscape, trade requirements could change overnight and we are 10 years behind other countries in terms of the toolkit that we have access to."*

New Zealand government funding and influence – Medium

A common theme discussed is the 'flip-flopping' of government policy between parties in power. This can limit traction in projects and derail work if it does not align with the current government vision. 'A Lighter Touch' program was highlighted as a joint-funded venture toward a 'softer' approach to crop protection. Many had positive views toward this project and saw the benefit of research to increase the 'toolbox' of crop protection. This funding, unfortunately, has a completion date.

Policy 'flip flopping' was mostly discussed within the environmental sector. Some participants felt that a longer government term may enable further traction. Long-term cross-government policies were also discussed as a tool to bring stability and reassurance to growers to work towards long-term goals.

> *"Big parties should agree on (policies) and say that there's a long-term goal here for the greater good of the country."*

5.2 Economic

Potential loss in profit – High

Some participants interviewed stated that some growers are producing food at a higher cost than the income received. One participant commented that the demands globally for most horticultural produce are down due to a recession in many countries. This not only reduces the economic margins of produce, volume of produce sold but also has an impact on the decision of how much is produced the following season. This results in limitations to invest.

> *"Profitability is the largest issue in the vegetable sector, and the ability to invest"*

Few growers can take risks on new crop protection strategies within the current economic situation. One participant stated that if their crops fail or do not produce the predicted yield, they may fail financially. Many saw this as a barrier to the uptake of change. It was highlighted that biopesticides can cost more than synthetic pesticides and, at times, have less efficacy. Some people felt there was little incentive for growers to try biopesticides, as they are not getting any economic incentives to reduce synthetic chemicals currently.

On a domestic level, growers are 'price takers' with supermarkets setting these prices. Participants did not mention any financial incentive from these supermarket distributors to produce food with fewer synthetic pesticides applied.

> "*They (growers) are a price-taking industry, they get told by the supermarkets what their produce is worth, which is not great for the long-term survivability of this industry."*

No international markets were highlighted specifically requiring the use of biopesticides, with a reflection of higher profits. Organics was discussed as an example of a model that does work. Often, quality or yield is reduced when you manage your crop organically however, there are premium prices for this produce.

Crop protection company expenses – High

Manufacturing and regulatory costs to agrichemical companies are a large cost participants stated. When speaking to agrichemical participants, the production of biological products is expensive. The starting of a culture (fermenting, colony), specialised equipment, and storability are often more specialised (environmental conditions) for biopesticides. The shelf life of biopesticides can also be shorter than some synthetic pesticides.

"It's a living organism, I'm (agrichemical company) trying to formulate it for environments with temperature fluctuation, UV fluctuation. Then there's manufacturing, they are not simple to produce in most cases."

Synthetic chemistry is still the favoured crop protection strategy in NZ. Some suggested it is challenging to make a business case to invest and manufacture these biopesticides with a limited market currently. One participant commented that with biologicals, this can be a challenge to ensure the stock is at the correct cultured volumes when required by growers. If the supply is not present when growers desire it, this can result in a lack of trust in a product by growers as the product may not be available when required by the grower.

"*You have to manage it (biopesticide production), so you got the supply at the right level when you need it, if you stuff that up and your colony collapses, or production stops, you're gonna lose your market"*

All representatives from the agrichemical companies had a strong view that government agencies are hindering crop protection evolution. The duration and cost to get new molecules onto the NZ market are lengthy and expensive compared to other countries. One interviewee expressed they were 'scared' for NZ as some companies are reluctant to apply for registration in NZ.

*"A risk that the proprietary companies might start pulling away and say we aren't going to bother with New Zealand, that scares the sh** out of me to be honest"*

Cost of biopesticides – High

Many participants stated that biopesticides were expensive, while no participants saying that they were cheap. Many viewed the cost of these products, which was highlighted in the section prior, as a large barrier to adoption. As previously discussed, biopesticides are often more expensive to manufacture and is reflected in the retail costs. Simply, it was viewed that the incentive to change to biopesticides was not economically present.

"They (biopesticides) cost three times as much as the synthetic pesticide and they are only 50 or 60% effective."

Agricultural retailer structure – Medium

During some interviews, it was highlighted few independent agronomists are present in NZ who are not linked to a sales target. This structure was discussed as a potential barrier to the integration of IPM and biopesticides. Some felt that the use of scouting and potentially applying fewer products in an IPM program may reduce sales for these individuals. A question of a conflict of interest was expressed between a sales target and what is the best approach for crop protection.

> "*Biggest limitations we have are a huge chunk of our agronomy advice to the industry comes from companies more focused on selling products rather than supporting growers"*

Although not all retail sales agronomists are like this, it does pose the risk to one's integrity. During many conversations, it was addressed that there is no formal training for these roles and the knowledge is very diverse within the industry. Formal training was highlighted as a tool to bridge the range in knowledge. Many participants could see a benefit of independent agronomists, particularly when implementing IPM strategies. Many highlighted the program in the UK (Facts and Basis) as a world-leading program for independent agronomists. In some interviews, I asked if NZ could adopt this system, and many thought that at our small NZ scale, it was not probable. Some participants also discussed that this system was paramount to many retail business models.

> *"I don't think those companies (rural retailers) can afford to do anything different"*

A participant commented that if NZ adopted independent agronomists, there would be a further cost to growers for this service. It was questioned, particularly in difficult economic environments, if growers would hire an agronomist or do it themselves. Some suggest that some growers do not have the knowledge to do this, which could result in risks of further chemical resistance.

> *"You (grower) used three of those fungicides in a row, that is against every rule in the book, how did you (grower) not know that? The case often is, I didn't want to pay an agronomist"*

Market access – Low

Market access was discussed in Section 5.1 in-depth. Today's market access was believed to be ‘Low’ risk and did not account for the future market challenges around access, which was discussed in Section 5.1 which was considered ‘High’. Very few people spoke of current markets that NZ were unable to access due to our crop protection strategies.

5.3 Social

Consumer demands – Low (Domestic), High (International)

It was evident from all interviews that consumers are more interested and demanding where their produce comes from compared to the past. A theme from the interviews was that consumers are not only looking at the growing practices but the entire business which may include animal welfare, slavery, and sustainablity goals. Consumers want to align their values with the growers they support and purchase from. This has been expressed to impact government and import rules internationally to reflect consumers concerns. An overwhelming sense from participants was that each country prioritize different factors for their produce. For example, China has a strong focus on phytosanitary, while the EU focuses on MRLs in produce.

Many participants described exporting as challenging and that it always will be due to the vast variety of consumers. Comments were made that given our customers are hugely diverse, this complicates NZ growers decisions on farm compared to some countries that could be more domestic supply-focused. Many people spoke of GlobalGap as a tool to ensure farming systems meet not only MRLs and food safety standards but also ethical and sustainablity targets.

> *“Consumers want to at least feel like they are receiving product from sources they agree with. The requirements to meet exporting markets are going to grow so much, not just how you are growing your crop, crop protection you are using, it is going to be a much more holistic approach*.”

During the interviews, I concluded that NZ consumers are less demanding than international consumers. The main reason highlighted is that people living in NZ expect food to always be safe, and they trust domestic growers. Consumer demands domestically were scored ‘Low’ because of this. It appears overseas consumers ask more questions due to a lack of trust. A

global trend with all consumers is that they are price-driven. This was a very strong theme among all interviews.

> *"30% of New Zealanders can't afford to put food on the table for their family. So they do not care whether that food was produced with or without pesticides, as long as it's cheap and safe, they'll buy it."*

Grower perception and trust – Very High

Three main themes were discussed in the interviews:

- Growers mindset to change
- Grower knowledge networks
- Growers mindset to IPM and biopesticides

A strong theme was that growers don't like change unless required. In many cases, when asked where growers were on the adoption curve, many viewed NZ growers as late adopters or laggards. The word 'crisis' was used in almost half the interviews to express the reasons why a grower alters their practices. Key examples of a 'crisis' discussed were chemical resistance, a synthetic chemical no longer available, export rules altered or a pest or disease incursion. One participant stated he has seen this often but highlights that this approach is not always the best, as decisions can be rushed and mistakes can be made, leading to poor results and a lack of trust in a new method.

Growers take advice from people they trust, this can include a neighbouring grower, catchment group discussions, chemical companies, agronomists, levy organisations or markets. Most interviewed agreed that growers are heavily influenced by other growers. Instant messaging apps or social media were also discussed to be powerful tools for sharing knowledge.

> *"Growers learn best from growers"*

It is highlighted that some information shared by levy organisations or government bodies is not always tailored to growers which can mean growers do not attend meetings due to a lack of perceived value. Some participants concluded that this is a risk that knowledge may be found from unreliable sources.

Mindset on IPM and biopesticides was very different. Generally, more participants were willing to engage in IPM practices or discussions compared to biopesticides. All growers spoke to use IPM to some degree, while few use biopesticides. Multiple waves of biological products

have occurred since the 1980s. It was stated that many companies overpromised outcomes to growers which resulted in a lack of trust in biopesticides. Some growers are sceptical about trying again.

> *" Back in the 80s, we completely overpromised and underdelivered, and then in the 90s, we had another round of slightly overpromising and underdelivering, and now we've got the third bandwagon"*

Many discussed growers perception of what a biopesticide is, as a real challenge. Some participants discussed that a risk of a lack of perception could mean biopesticides could be misused and misinformation is shared on these informal platforms. Although these platforms can be highly valuable, they can also be a real barrier if incorrect knowledge is shared among a group.

> *"There is a perception problem with biopesticides cause some growers have tried to use them in the identical same way as they use their chemistry (synthetic), and of course it doesn't work, then they go it's sh**, its not effective and they will never go back to it again and tell their neighbours about how crap it was."*

Not all biological products need to be registered on the NZ market. This can lead to some 'snake oils' on the market with poor results achieved. Many agrichemical and biological experts saw this as a threat to biopesticide uptake due to the inconsistency in regulation of these products.

> *"I remember being in Brazil and biopesticides were just exploding…the regulations were not clear, so people were producing things (biopesticides) in bathtubs and small fermenters and trying to make a go of it."*

Growers have relied on chemical crop protection for a long time. Agrichemical companies and biological representatives highlighted that biologicals should be applied differently, with efficacy often being less than synthetic chemistry. Biopesticides are often expensive compared to synthetic chemical controls as well This is not always explained to growers and many saw this as a large mindset barrier. This poses a real challenge to persuade growers to utilise these products if there is no clear economic benefit.

"It (biopesticides) is going to take time and investment, it's hard when the market is not as attractive as it is for synthetic chemistry... yet"

Industry collaboration and support – High

There was an overwhelming agreement that there is a lot of knowledge within the NZ horticultural sector, but not enough knowledge in biopesticides or IPM. Many discussed the largest hurdle was identifying the key people within the industry who had this knowledge to lead change. This feeds back into the discussions in Section 5.2 regarding no formal training of agronomy advisors. Upskilling the industry to support growers was identified to take time but critical to grower success.

A common theme was that the industry has unclear or inconsistent messaging to growers. In some cases, it was described multiple sector groups undergoing very similar research and not utilising group funds. It was highlighted that levy organisations operate under different mandates, which can make it challenging to group fund projects. It was clear that all participants were open to working collaboratively. An example discussed was the VICE, which is co-funded by the Ministry for the Environment, and has developed a research farm to invite working groups and wider industry on site. This collaborative approach was discussed as a success with the industry to share a space and knowledge collaboratively within the vegetable sector.

"*This last time potatoes and vegetables got together (joint funding for international IPM advisor visit), last year it was arable crops and vegetables, so you know, there's definitely some advantages if they pool their resources. There's some commonality not just with the pest, but with the things that eat the pests and the pesticide issues."*

Domestic supermarket requirements – Low

NZ has a duopoly of supermarkets. During the interviews, there was no indication of supermarkets domestically having a focus on supporting produce with less pesticides or softer chemistry applied. I tried to speak to one of the dupoly supermarkets in this study, but was unsuccessful. I did speak to an independent vegetable shop owner, who stated that many produce retailers do not want to open discussions with consumers about pesticide use. A

participant from Australia commented about the supermarkets there, which shared a similar approach.

> "*The supermarkets (Australian) don't want to mention pesticides because it is not a marketing tool at all unless they can get 100% of their product in one way.*"

As previously discussed in Section 5.1 and 5.2, NZ exporting markets have a stronger influence on our crop protection strategies. Domestic supermarket requirements is scored 'Low' for this reason.

5.4 Technological

Broader 'toolbox' required – Medium

Horticulture is very diverse, and many individuals discussed about the continuous journey of integrating other crop management tools. An overwhelming theme discussed was how reliant growers are on chemical controls. A concern was chemical resistance; many saw that the use of a diverse 'toolbox' could reduce this issue. Most felt chemical use will be less in the future but will always have a place within the 'toolbox'.

> *"Growers are gonna have to use several different strategies to be able to manage them (pests)... Gone will be the days of just using chemicals"*

Technology was identified as a tool to reduce the reliance on chemical controls. Many people were excited about technology to decide if chemical controls were necessary. Technology such as insect traps or insect modelling tools was a key example that could be widely adopted. Mechanical controls such as drone or inter-row spraying, flame, steam or electrical weeding machines were also discussed as tools which could be used in NZ.

> *"Traps that are detecting pest flyovers at night, so you know when you need to apply an application (chemical)"*

Genetic modification or engineering was not discussed in depth. There was no specific question about this topic; however, most who discussed this were open about the development of these tools to some degree. Multiple participants who spoke in favour of this thought that pesticide use would decrease with the introduction of genetic modification or engineering. They also stated that this will be a slow integration and unlikely to be a key management tool within the next ten years.

5.5 Legal

Constrainted regulation systems – Very *High*

A question asked to every participant was whether the regulatory process for new chemicals was aiding or hindering the crop protection strategies (Appendix 12.1). Almost all participants said hindering.

The length of time spent registering new molecules in NZ compared to other countries is considerably longer. A participant expressed their frustration around the duration, but also the lack of communication between industry and regulatory agencies. Many interviewees spoke of no guidelines on timeframes, which was a large challenge to achieve internal pipeline milestones for these products and furthermore receive a financial return. Multiple comments were made about proprietary companies feeling discouraged and may not register products in NZ due to these challenges.

> "*One of our products, you know, I was supposed to launch it the year I started, 5 years ago and I'm still waiting"*

It is noted that the EPA and ACVM are not aligned with their risk management assessments and have little strategic oversight. It was also highlighted that the EPA operate under a very high risk-averse attitude. This results in mass frustration within the industry. One of the issues is that some of the ecotox models used to assess risk are outdated and at times do not align with today's environmental risks. It was stated that updating some ecotox models takes financial investment and time which some interviewees felt this government agency may not have currently.

> *"They (EPA and MPI) have been trying to get the legislation changed for the last 5 or 6 years."*

It was stated that the communication is fragmented between industry and these government agencies. Industry expressed a sense that regulators have little open dialogue with industry around the decision-making process. It was noted by one regulatory participant that industry knowledge is invaluable when assessing risk for regulatory agencies and should be utilized in determining risk in some situations prior to the final decision being made.

High staff turnover was also highlighted as an issue with knowledge often lost in many government agencies. It was noted that many knowledgeable staff originated outside of NZ,

when COVID-19 occurred they moved back to their origin country, which increased this issue further.

A review is underway for the EPA with multiple recommendations made (Ministry for Regulation, 2025). From this review the main issues that align with the people I interviewed are: lack of strategic direction, long application queues and completeness of the approval path across the two regulatory systems. One participant who works closely with the regulatory agencies felt that although the review has started, it is a long road to change.

'It will take two years before you start noticing the benefits"

Australia was highlighted as a country that has higher cost recovery than NZ. It was noted that the EPA legislation has particular rules around cost-recovery which limit applicants from paying high cost-recoverable fees. The agrichemical participants expressed they were very open to putting additional funds toward registration if this process were faster.

"In other countries the EPA or regulatory bodies are able to recover up to 80% of the costs of a registration from the application. This generates a lot of revenue that they can put back into it to get more people in to get things (applications) put through quickly. Our legislation has strange little things in there that talk about not setting any prices, which would deter people from putting an application in."

Regulatory entities lack biopesticide knowledge – Medium

In the previous section, it was discussed that these regulatory agencies have high turnover and as a result, lose knowledge. One agrichemical spokesperson commented compared to Europe, the regulatory process is heavily suited to synthetic chemicals. Multiple people question the knowledge of biological compounds in these agencies and if they are fairly evaluated. It was discussed during an interview that 'A Lighter Touch' is undergoing a review of international regulatory processes, particularly how biological products are assessed. It is hoped from the interviewee that this will increase collaboration across agencies and industry to increase knowledge of biologicals.

5.6 Environmental

Chemical resistance management – Very High

Chemical resistance was one of the highest risks among all groups of participants. Many expressed extreme concern around this issue, with the possible threat of losing an effective tool in the 'toolbox'. Agrichemical company participants spoke a lot about the stewardship of these products and the need to protect synthetic chemistry from potential crop resistance. This industry expressed a key concern around education regarding the long-term effects of poor management practices within the wider industry. Levy organisation representatives tended to agree with this. Some interviewees expressed a shift toward IPM and biopesticides as a means to reduce the risk of chemical resistance. These conversations flowed onto the slow process of registering new molecules which is believed to hinder chemical resistance management. Among the agrichemical representatives, there was a large investment within biopesticides which had a fit within the horticultural sector. A large barrier to getting these to the market is the regulatory process, followed by the growers view toward these products.

"The global prediction is like a $25 billion market by 2030 for biologicals"

Levy organisations are putting a lot of resources into education and management resistance strategies to enable options within the growers 'toolboxes'. One participant who did extensive research in chemical resistance believes resistance to be a lot higher than predicted.

"I think what everyone was surprised with was the degree of resistance there was and how widespread it was "

Some individuals who were in support of IPM and biologicals saw chemical resistance not only as a risk but also as an opportunity. The idea of chemical resistance as a 'crisis' was discussed which could open the door to other crop protection strategies potentially being used.

Synthetic chemical impacts on the ecosystem – Low

One question in the interview discussed the impacts of synthetic chemicals to the ecosystem (Appenidx 12.1). This had a mixed response. A moderate proportion of participants had a clear response that there would be a benefit to the ecosystem, while some participants had no opinion or did not think there would be a benefit. The people who thought there would be a positive impact were mostly from levy organisations or biological experts, while the people with no opinion or no impact were mostly within the agrichemical companies or growers.

This topic was scored as a 'Low' risk as there was not a strong opinion toward the deterioration of the ecosystem by synthetic chemicals; therefore, this will not be a strong lever to changing crop protection strategies.

Climate change – Low

Few participants identified climate change as a large issue for crop protection changes in the horticultural industry. Over time it is predicted that climate change will alter pest and disease abundance and locations as regions begin to warm. This in most cases will be a gradual change and not a 'crisis' effect.

Natural disasters were discussed multiple times. It was highlighted that horticulture, particularly orchards, are prone to high damage in natural disasters. One participant highlighted the Cyclone Gabrielle and floods in Hawkes Bay in 2023 as an example of climate change impacts. There is no dispute that this was devastating however no one discussed this as a driver to a change in crop protection.

6. Discussion

6.1 Political

Geopolitics

It was not surprising that geopolitics was discussed in depth given this study was undertaken in 2025. Donald Trump in power, conflict with large nations (China, USA), wars, weakening WTO and tariffs imposed are all frequently mentioned in the media. Many participants spoke of these topics as a real concern for our economy due to being an exporting nation.

NZ is a small nation with sadly not a lot of political power and has little impact on many international situations which effect geopolitics at a rapid pace. NZ's role historically which aided in trade has been the initiator of trade agreements and fostering relationships. This has been a good strategy to obtain market access and lasting trade relationships. Trade affairs are out of the scope of direct influence for most of the industry. Reliance on politicians and our NZ trade advocates play a critical role to gaining market access.

A key result worth highlighting is the world perceives NZ as a trustworthy country that is 'clean and green'. Consumer demands more than ever are being reflected in regulations. It is predicted that regulations for markets like the EU will align with a more 'holistic' approach.

Maintaining these two images through a softer crop protection approach is something growers and industry can influence.

NZ government

NZ is emerging from a protracted recession with tight monetary policies to bring down inflation (The Treasury, 2025). The Budget 2025 provided few funds allocated to farming and will likely limit research projects and possibly crop protection innovation. Industry and growers need to align on some key messaging and lobby the government to gain traction and furthermore funding for key projects. The main funding top-up to enable further updates within the EPA ecotox models will be discussed in Section 6.5- Legal.

A longer government term was discussed and most agreed it would enable more stability and achieve long-term goals. Dal Bó and Rossi (2011) concluded that shorter government terms resulted in a politician discouraging effect as the investment payback on policies is not always met when compared to longer terms. The duration of the term often impacts the timeframes for policies imposed, implying a longer term would have long term goals (Dal Bó & Rossi, 2011). Although there was no literature to suggest the optimal re-election timeframe, many interviewed felt a term of at least 4 years would help provide better longer-term policy for farming and the environment. Another conclusion drawn from some interviews was the need for cross-government policy for 'wicked' problems such as sustainability, education and health (Cash et al., 2006; Siemers & Serban, 2025). This process involves considerable collaboration among key political groups which can be extremely difficult in practice with the roles of power in play. The horticultural sector cannot solely make these changes, these require national support.

6.2 Economic

Potential loss in profit

Many interviewed highlighted that growers are not currently making a profit. Implementing a new crop protection strategy by many growers is perceived as 'risky' economically. This poses a large roadblock to the incentive to experiment with high risk to their business survival. Many papers suggest that the use of IPM and biopesticides may reduce chemical applications applied to a crop and furthermore, reduce costs (Horne & Page, 2022; Wright et al., 2017). Examples of the Apples and Pears industry and TPP integrated controls within the literature review showcased this (MacDonald et al., 2022; Wearing, 2019). This is a perception issue as many have not tried IPM or biopesticides extensively. These tools however require education

and time to crop scout. If growers are financially strained or time poor these methods should not be implemented with the risk of failure and mistrust being too high. Timing is everything.

Crop protection company expenses

The complexity and expense to produce biopesticides is high and reflected in the retail price. Globally, synthetic chemicals are still favoured, the additional costing of biopesticides in NZ makes it less favourable from a financial standpoint for growers to adopt. Knowledge of biopesticides is lacking and education within the industry is key to building a market and business case in NZ.

It is concerning that multiple people within this industry expressed that NZ is not desirable to get products registered. The registration process was expressed as one of the largest hesitations to launching a product in NZ. This would have considerable adverse impacts to NZ growers 'toolboxes' if products are not registered. Many agrichemical representatives expressed they were open to paying additional funding towards the application process if it were quicker and more straightforward.

Cost of biopesticides

This was a large barrier to growers trying these products which has a flow-on effect to the perception of a 'potential loss in profit'. Without a larger market and return on investment by the production companies, prices may not change. This will be a large challenge for adoption in a strained economic climate. Little recommendations can be made for this current situation.

Agricultural retailer structure

A conflict of interest was addressed among mostly growers and levy organisation representatives around the retail structure. Agronomy advisors often being linked to a sales incentive was seen as a barrier to IPM. Although this could be argued as true, NZ is a small country with entrenched business models that cannot be changed overnight.

A solution to address this, is to provide formal training among this group of advisers to build credibility not only for individuals but as an industry. One grower expressed he did not trust advisers due to the sales connections that these roles have. A training plan with incorporated IPM and sustainable farming practices may reduce this perception. Although *Facts and Basis* in the UK is an excellent program, this system is unlikely to be financially viable in NZ and an adapted version could bring consistent messaging and credibility to this sector.

Market access

The larger threat is the future market access not the current. Little recommendations came of this. Future market access is discussed in length in Section 6.1.

6.3 Social

Consumer demands

It was clear during all interviews that consumer demands are increasing and can be reflected in some countries import requirements. Overall, there is a trend, particularly within the EU to take a holistic approach to food production with a reduction in chemical applications. Growers need to follow market trends to ensure they meet market demands to maintain a viable business. Growers should evaluate their crop protection strategies to ensure that they align with markets. Currently, the largest pressure is lower MRLs, this may result in biopesticides and IPM being utilised as tools to achieve these targets. Global Gap (or equivalents) is likely to be more critical to prove practices are indeed aligned with consumer requirements.

Grower perception and trust

Growers perception and trust were one of the largest barriers identified to the adoption of IPM or biopesticides. Many viewed NZ growers as slow adopters or laggards to change. Market requirements were a common reason to change. Changing during a crisis is not ideal however often a reality. Engagement with growers before a crisis is a better approach but, there must be an incentive. Currently, biopesticides are often more expensive than synthetic products with no market requirements specifying the use of biopesticides; therefore there is no economic incentive. If lower MRLs were to occur, biopesticides would be more appealing. IPM however has more incentive as there is a view that fewer chemical applications could be required which may reduce costs.

Perception of biopesticides by growers is not always the reality and a real roadblock to implementation. A lack of knowledge within the industry and among growers enables misconceived perceptions. Education and support is critical to the success of biopesticides and IPM practices. ‘Snake oils’ with no scientific data to back up claims can be highly damaging to biological product perceptions. Science-based education around biologicals will help growers identify these products in the market. IPM is a journey due to the vast scale. Some questioned, if growers knew the fundamentals to IPM such as beneficial insect identification which can be an important element to IPM. Many are also not aware of the application differences with biopesticides to achieve the best outcomes. Fundamentals must be learnt before implementation. During practice changes, growers need support from experts

and industry to have the up most success. Unfortunately, from these results, the industry as well, has a large knowledge gap. This poses the question of where growers will get this support.

Technology could be highly valuable during the implementation process. The use of instant messaging groups or social media pages can be an effective tool to share knowledge and experience, if managed appropriately. Including the international experts within these channels can provide support while the industry is upskilling in these fields. For example, a grower interviewed is in a WhatsApp group with other farmers and experts to share regional knowledge and challenges. This example provides well-rounded discussions that include an expert to provide context and facts if required. This reduces the risk of misinformation being shared. Communities built through change can be highly valuable to build trust not only in the process but within the people around them.

Industry collaboration and support

Most of the industry does not have enough knowledge around biopesticides or IPM to educate growers. This has led to mixed messaging in the industry and furthermore mistrust in these methods. Industry need to upskill in other crop protection strategies and obtain some key messages for crop sectors. This may mean additional specialised extension-based roles are required. Utilising the Crown Research Institutes and Universities research is a key way to understand these complex systems and tailor the messaging toward a grower audience. Feeding information to these institutes is also important to drive research which is industry-specific. Figure 4 highlights that the knowledge sharing pathways are not always linear and rather collaborative. Utilising international experts to upskill the identified domestic experts within crop sectors could be a way to build networks of support within the industry. Multiple levy organisations have done this recently with inviting Paul Horne (IPM Technologies) from Australia to speak to growers about IPM. This is an excellent example of building knowledge within NZ when there are few experts currently. It is important to continue the channel of communication with these international experts to build a network of NZs own experts in these fields.

Industry was in agreeance that there could be benefits with collaboration across industry. A challenge is that levy organisations operate under different mandates which may not align with joint projects. An example of collaboration is VICE. Growers are welcomed on site to see the research, this is an incredibly powerful tool. Growers in this current economic climate are risk-averse however, like to see things in physical form before implementing them within their own farming system. The use of funding like this enables growers to build trust in new crop

protection strategies, but limits their own economic risk. This also builds a connection with industry leaders for additional support when required.

Domestic supermarket requirements

Engaging with produce retailers was a real challenge with only one out of the six contacted, responded. Currently domestic supermarkets and consumers will not drive crop protection changes to a softer approach. This is due to a level of unawareness in domestic consumers and lack of dialogue with distributors around this topic. Change may occur domestically however this will be driven by international customers lifting the benchmark.

6.4 Technological

Broader 'toolbox' required

Many participants highlighted great risk to the industry if chemical controls were no longer effective. Technologies could be a powerful tool to limit the reliance on chemical controls.

Justification of chemical controls to some markets may be a future requirement. Technology such as trapping and modelling of insect and disease pressure to justify chemical applications has a particular fit for IPM and biopesticides. These tools will provide more information to growers to make an informed decision. Biopesticides may be utilised when low pressure of a pest is present and save synthetic chemical controls only if the population builds. This may limit the application of pesticides throughout a season and enable a diverse beneficial insect community which can favour an IPM approach. Further education around technology is likely to be required from growers to fully utilise and implement them alongside biopesticides or within IPM. This could provide transparency to international customers through the justification of applications.

Although the use of mechanical controls are highly valuable many growers are unlikely to invest in these machines currently. Selective or drone sprayers are also heavily reliant on chemicals which do not diversify the 'toolbox'.

6.5 Legal

Constrained regulation systems

Majority of participants agreed this system is not working and hindering the farming industry of valuable tools for crop protection.

From research by Loan (2023) it is highlighted that the NZ ecotox models are outdated and many countries have updated their models to reflect the current environmental and human health risks. Updated versions are required to enable accurate assessment of risks on new molecules and furthermore ensure the protection of the environment and people.

Through the literature review, it was highlighted that the HSNO Act limits of cost recoverability and the EPA is underfunded for the number of applications they receive (Loan, 2023). Table 2 highlights NZ is very conservative in cost recoverable fees compared to other international agencies. Throughout the interviews, the applicants were open to paying further fees if wait times were shorter. Quicker registration will aid in return on investment by the developer and could reflect in a cheaper retail price over time (Section 6.2). Changes of the HSNO Act to increase cost recoverability per application to recycle funds into the investment of new ecotox models and systems is advised.

Finally, the communication between regulatory agencies and within industry is fragmented and dysfunctional. The regulation system has not operated effectively for some time and there are a lot of negative views and a loss of trust. Trust between all parties will take time to rebuild. Transparent communication by regulatory agencies throughout the application process to applicants is important to building this trust.

Empathy for these agencies is advised as it will take years to see the true benefits of some of these changes proposed in the review recommendations.

Regulatory entities lack biopesticide knowledge

It was highlighted through multiple interviews and through the literature review that these assessors positions require a specific skill set which globally can be a competitive employment market (Loan, 2023). ‘A Lighter Touch’ research connected with international regulatory agencies to explore approaches to biopesticides globally is a proactive approach. The conclusions of this study have not been published yet. This method however bridges the gap of knowledge innovatively and cost-effectively which can be adopted domestically.

6.6 Environmental

Chemical resistance management

Chemical resistance was identified as a large risk to horticultural crop protection. Many agrichemical companies highlighted the need for stewardship and best practices when

applying synthetic chemicals. Resistance limits chemical options for growers to utilise and poses the risk of further resistance but offers opportunities to explore other management practises.

Education around the modes of action of products is key to limiting resistance. The use of biopesticide applications in rotation with synthetic protection could be a strategy used in some crops reducing the risk of resistance and residues on produce. Education to growers of cultural and biological controls will aid in less chemical reliance.

A functioning regulation system will also help this issue. The introduction of new modes of action and molecules will enable more control options. Although it is not suggested to only utilise chemical controls, this may enable more biopesticides to enter the market.

Levy organisations have done extensive work in educating growers and they should continue to do so. Chemical resistance is not going away, growers should become adaptable and experiment with other tools.

Synthetic chemical impacts on the ecosystem

Surprisingly, synthetic chemical impacts on the ecosystem had mixed views. It is highlighted that some biases may have been in play when asked this question. I propose that little change will occur due to any environmental degradation unless regulation is imposed. The wider group shared more concern around chemical resistance which is a larger driver to change.

7. Conclusions

Through a literature review and interviews it is clear there is a wide range of opinions however many followed themes. The main concerns and issues were highlighted by most people but the solution to these issues differed.

The Pestle analysis highlighted key issues within each factor group and a mindmap was produced (Figure 9). Dotted lines show the complexity of factors having a wide influence. To conclude the findings of the Pestle analysis were put into two sections; *People* and *Mechanics.*

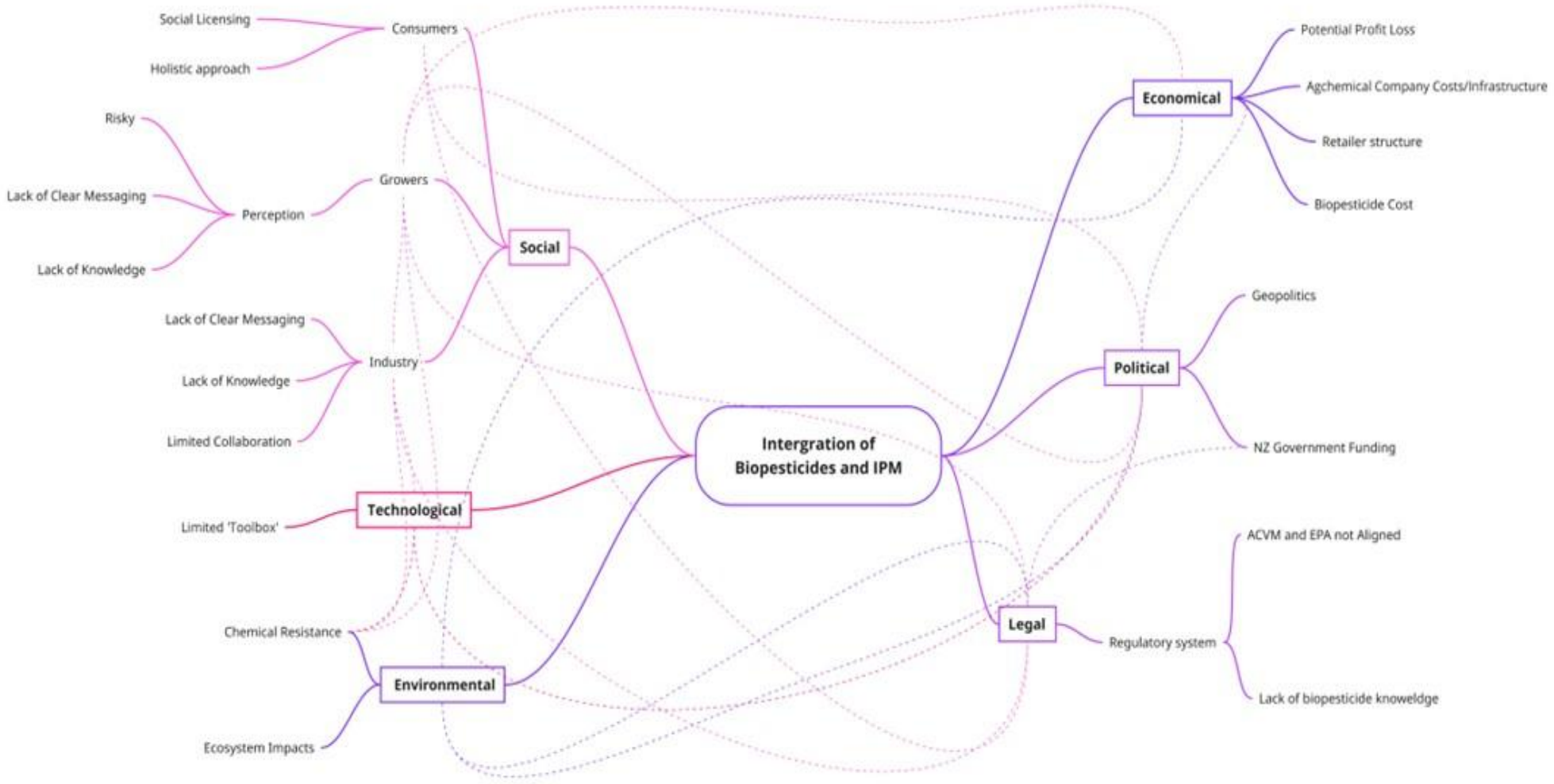

Figure 9: Mind map of key factors from semi-structured interviews. The directly linked (____) factors are based within a PESTLE analysis with the dotted lines (…..) to show the interaction between factors

People

Change management

Mindset change is the largest barrier to implementing IPM or biopesticides into growers practices. An overwhelming amount of growers do not like change, as such it is a significant barrier. A 'crisis' or a change in export requirements is necessary to make the greatest change to crop protection.

Growers perception and trust of biopesticides is low. A lack of education and support results in unrealistic expectations when implementing these methods. Change in this perception will take considerable time and energy from the industry. Currently, there is little incentive for growers to adopt biopesticides as there is no perceived economic benefit. Unless there is a 'crisis', biopesticides will struggle to obtain market share.

IPM is further ahead in adoption as there are more economic incentives. A perception in reduced chemical costs is a key driver. IPM is on a continuum, growers can change slowly as their knowledge builds which can reduce the fear imposed by change. Extensive knowledge is required to fully implement this strategy. The use of clear messaging, collaboration and a science-based approach will aid in this integration.

Education

Education is key to providing a clear message. The industry as a whole needs more knowledge to support growers. The identification of key experts domestically is important to establish clear messaging. Key experts need to build learning strategies collaboratively, the connection with international experts and tools is important to enable a global context and provide support to these domestic experts. Learning tools must be widely diverse to capture the wide industry. The use of international tools could limit the economic barriers. This may require additional extension roles, particularly during the implementation phase.

Levy organisations operate under different mandates however key crop protection themes should align throughout crop groups. Key experts must collaborate with levy organisations. Agronomy advisors should require formal training. A benchmark of knowledge for this group should be established to provide credibility, consistency and instil further trust within growers. The entire 'toolbox' should be included in this learning.

Growers have a mixed view on IPM and biopesticides with a wide range of knowledge. Open dialogue between the key domestic experts should be readily available to growers and industry

for support. Wider industry learning will introduce a web of connections and knowledge with less reliance on the experts to support industry over time.

Science-based approach

Science-based learning can help keep the industry honest on product expectations. This can manage risks to growers prior to implementation. ‘Snake oil’ products often do not have sound scientific backing, growers may ask more questions prior to purchasing these products if a science-based approach is undertaken. This will help separate effective biopesticides from the ‘snake oils’.

Collaboration and communication

Communication and collaboration within sectors could improve. Clear messaging is important with a multi-directional flow of dialogue between experts, industry and regulators. Growers during the transition phase will require a lot of support. Ensuring support from industry that they trust is readily available is essential. Support must be versatile to growers and adapted to their needs.

Pooled funding should be considered were possible. An example could be hosting an international specialist for multiple events during one trip or combining events which have similar pests and pesticide issues.

Although a longer government or cross-government policies would bring advantages to the agricultural sector, this requires national-level support.

Resistance management

Chemical resistance was a common theme of concern. Growers rely too much on this control and have become vulnerable. Resistance education needs to continue by levy organisations. Education and implementation on a wider ‘toolbox’ is important to be less reliant on chemicals and bring versatility to the industry.

Finally, a well-functioning regulation system is paramount to managing resistance.

Mechanics

Regulations

The EPA is not functioning well and is currently under review. This system is key to a wider 'toolbox' and chemical resistance management. Many issues stem from the HSNO Act and the outdated ecotox models.

Many ecotox models used are no longer fit for purpose and outdated. Models are restricting assessors from evaluating new molecules effectively. The outdated ecotox models need to be replaced.

The HSNO Act has strict rules around cost recovery. This Act should be modified to increase cost recoverability from applicants. Funds should be recycled into updating systems and the ecotox models to increase efficiencies. Participants interviewed who make applications are open to this option if a more effective system is achieved.

The use of the GlobalGap program could bring grower transparency to customers. A focus on holistic approaches should be strongly considered to reflect some key markets focusses and continue to have strong market access.

Technology

AI and modelling are advancing fast and is providing many opportunities. Trapping and modelling tools that can help growers identify risk of pest and disease damage will be advantageous to IPM and biopesticides. These tools could aid in the reduction of chemical reliance.

The investment of highly selective machinery may reduce the volume of chemicals applied but not always the reliance. All machinery involves significant capital investment. In the current economic climate this is not viable for many growers.

Limit growers risk – research farms

Growers are currently economically risk-averse. Utilising research farms or grower-hosted days is a tool to expose growers to other options without the financial risk. An example of these are VICE or FAR research sites. These sites must ensure research is practical for growers to see value. It is acknowledged that these are expensive and not possible for every crop sector; grower-hosted days can provide similar value for smaller crops. Hosted days also enable the ability to build a trusted adviser network.

8. Key recommendations

These recommendations derive from the findings of the literature review and interviews. The recommendations are split into *People* and *Mechanics* to provide clear messaging on how to integrate IPM and biopesticides into the horticultural sector further.

People

- Identify key experts within NZ for IPM and biopesticides and make a committee. Connect these experts with key international specialists if there is knowledge gaps. Experts collaborate and identify key strategies to upskill and share knowledge for the wider industry.
- Experts identify international learning platforms to be used to increase biopesticide and IPM knowledge for the wider industry and utilize pooled funding. A diverse range of learning tools is important.
- Experts need to be readily available to the wider industry for advice during implementation.
- Agricultural retailers and agronomists should produce a formal learning platform as a baseline of knowledge for agronomic advice. This should include a broad 'toolbox' approach.

Mechanics

- Amend the HSNO Act to increase cost recoverability. EPA to increase cost recoverability from applicants. Recycle funds to update the ecotox models and systems to reduce delays for registration.
- Further integrate GlobalGap into export-dominated growers, prove ethical and sustainable measures are met.
- Utilise technology (modelling, traps) as a tool for the IPM and biopesticide implementation strategy.
- Government and levy organisations continue to invest in research farms. Have a strong focus on practical research and technology which can be easily implemented on growers farms which focuses on a softer crop protection approach.

9. Limitations

Geopolitics was discussed in every interview. NZ is a small, isolated country with a minor level of political influence compared to the larger countries. NZ horticulture has little influence on these matters therefore was not discussed in the recommendations.

A lack of domestic supermarket engagement was a limitation in understanding domestic drivers more in-depth.

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12. Appendices

12.1 Appendix of Interview Questions

Background Questions

1. Can you tell me about your background in horticulture and what you consider to be your expert field?
2. What do you think the largest issue is in Horticulture?
3. What will be the main horticultural crop protection strategies in 10 years time? Will issues differ to todays issues?

Export Market

4. Globally NZ markets itself as 'Clean and Green'. Do you think the world views NZ horticulture in this way? Do you perceive NZ horticulture in this way?
5. In the next 5-10 years what requirements will there be to export produce?
6. In your view, if NZ utilized more biopesticides and integrated pest management what global markets would be most effected positively or negatively?

Domestic Market/ Public Opinion

7. In your opinion, what does domestic consumers and supermarkets care about the most?
8. If synthetic pesticides and fertilizers were used less; in your opinion what impact would this have on the land and consumers, if any?

Agronomic fit

9. What are a few words that come to mind for
    a. Biopesticides
    b. Synthetic pesticides
    c. Integrated pest management
10. What factors contribute to growers changing agronomic strategies and crop protection?
11. What do you feel are the most important opportunities and constraints of biopesticides and integrated pest management strategies if any?

Regulation, Levy, Private Sector

12. In your opinion are the levy operating groups achieving the outcomes growers want and need?
13. In your opinion, is NZ political and regulatory systems aiding or hindering in the evolution of crop protection?