A Lighter Touch Final Report

PROJECT TITLE: IPM programme for glasshouse tomatoes incorporating arthropod BCAs

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Executive Summary

Project Report-IPM programme for glasshouse tomatoes incorporating arthropod BCA's

Introduction: This project was a joint venture between the A Lighter Touch (ALT) programme and Tomatoes New Zealand (TNZ). The goal was to trial native and endemic beneficial insects to expand the range of pest control options for New Zealand tomato growers. In particular, the trials were to expand upon the research work carried out at Lincoln University with regard to *Engytatus nicotianae (E. nicotianae)*, in commercial glasshouse situations.

The project: After an initial false start (see 2.3.4.2 for more details) a project reset took place in July 2022. Bioforce Ltd became the project manager and a dedicated technician was appointed to collate data and to liaise with the trial sites.

In addition to the initial trials of *E. nicotianae* on Tomato and Potato Psyllid (TPP), this project was expanded to consider how *E. nicotinae* might work with other beneficial insects for whitefly control.

Trials occurred at seven different sites in both the North and South Island. Growers ranged from small family run businesses to large commercial operations. Feedback from each trial site varied, with both verbal feedback and hard data being collected.

The results: All trial sites were able to show that the use of bio-controls positively impacted upon their pest control. There is more detail on this is the crop economics part of the report (see section 1.3)

Key benefits (which are explored in greater length throughout the report)**:**

- Growers participating in the trials developed a greater understanding of pests and how they interacted with beneficial insects
- There was greater control of pests than with conventional agrichemicals
- The use of bio-controls had economic advantages over conventional control
- The use of bio-controls resulted in increased production and better fruit quality
- There has been increased uptake of bio-control by New Zealand greenhouse tomato growers.

Summary: This report provides further detail of the trials that took place. While there have been many learnings (as identified in the key benefits above) that have led to the creation of an IPM guide for greenhouse tomato growers, the intention was always for the guide to be a living document that would continue to be developed as further research leads to a greater understanding of how to use beneficial insect controls in greenhouse tomato crops. The trials that were part of this project have developed a framework for future research.

Some general learnings that could be useful in developing other projects that aim to create an IPM guide are:

- That the aims of a trial, especially when conducted in commercial settings, are likely to change over the course of the project
- What works for one grower might not work for another grower
- An IPM programme needs to be able to be adapted to different situations / attitudes and even from one season to the next. For this reason, it is a guide not a prescriptive manual.

- Learnings can change and be added to from one year to the next in a multi-year trial and that these need to be communicated annually and resources edited accordingly
- Developing an IPM guide is a journey with no specific end point as the learnings will continue to change and be added to even after a project has finished
- Not every grower will want to change their practices and that's okay.

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1 Introduction

The New Zealand (NZ) tomato industry is worth $151.7m (farmgate value as of 31st March 2025, according to TomatoesNZ stats) with around 99% of the tomatoes produced grown in greenhouses, and mostly for supplying the domestic market. There are around 140 growers spread throughout New Zealand.

Growers are expected to produce large volumes of a high-quality product in a manner that meets or exceeds market expectations.

The arrival of Tomato and Potato Psyllid (TPP) in New Zealand in 2006, and the need to control this new to NZ pest, severely disrupted the existing Integrated Pest Management (IPM) programmes.

Issues included:

- Controlling TPP with chemical spray applications disrupted beneficial insects being used for whitefly control.
- Resistance to existing chemistries was being developed by pests i.e. reduced efficacy of current pest controls.
- Some existing chemistry being removed from the market.
- A reduction in new chemistries being offered to growers.
- Increasing consumer resistance to agrichemical use in food production due to residue concerns.

The combined effects of the above issues resulted in decreased production volume and increased costs of production, leading to reduced profits and in some cases economic losses which had an impact on the business' survival.

The same trends have emerged internationally and have led to the development of comprehensive IPM strategies for the control of TPP that rely on the application of all the available tools in a cohesive manner.

A key tool within IPM is the application of arthropod biological control agents (BCAs). BCAs include predators that parasitise or predate pest species.

Due to NZ's regulatory environment with strict controls on the introduction of new organisms, NZ growers do not have access to many of the BCAs available to international growers. Previous efforts to import non-native species (eg. *Macrolophus pygmaeus*) resulted in great cost to growers and the application was unsuccessful in gaining regulatory approval[1].

However, there was the prospect of BCAs that are native or endemic to NZ that needed further investigation. Some of these were thought to be candidates to aid in control of both TPP and other pests common in tomato crops. Research was needed to see if these BCAs could be identified, tested and ultimately become part of an IPM programme for greenhouse tomato growers. This formed part of the basis of the project.

[1] See here for the EPA documents related to the application for *Macrolophus pygmaeus* https://www.epa.govt.nz/database-search/hsno-application-register/view/APP201254

Figure 1. Two of the largest threats to greenhouse tomatoes leave their mark. Remnants of infestation by whitefly (left) and TPP (right).

1.1 Background

The solution to the issues outlined above, was to look to our natural environment to identify native or endemic predators in NZ. These trial BCAs needed to have the potential for mass rearing and commercial greenhouse application.

Tomatoes NZ helped fund research student Emiliano Veronesi through his PhD to study the effect of one native predator on the common pest TPP. Emiliano's work was laboratory based and resulted in the publication of the paper 'Potential of the mirid bug, *Engytatus nicotianae*, for the biological control of the tomato-potato psyllid in greenhouses' by E. Veronesi et al in 2022[2]. This paper described the testing of *E. nicotianae* that had shown promise as a potential BCA.

After positive laboratory results, the recommended next step was to undertake trials in commercial greenhouses. This would give some assurance if the laboratory-based findings could be scaled up and be effective in commercial operations.

1.2 A Lighter Touch alignment

This project aligned with the overarching aim of A Lighter Touch (ALT); to mainstream the adoption of agroecological crop protection principles. The vision of TomatoesNZ, through this project, was to develop an IPM programme that any tomato grower can use to manage the major greenhouse pests.

The result was a joint project between Tomatoes NZ and ALT titled, "IPM Programme for Glasshouse Tomatoes incorporating arthropod BCAs." This report summarises that project.

[2] This paper can be found here: https://www.sciencedirect.com/science/article/abs/pii/S0261219422000370

2 Project Design

The project aimed to achieve four key objectives through the delivery of one or more sub projects. Those objectives and sub projects are summarised in Table 1 below and described further throughout section 2.

Objective 1	**Scope and baselines**
Sub project 1.1	Current practice
Sub project 1.2	Pesticide side effects
Sub project 1.3	Crop economics
Objective 2	**Filling knowledge gaps**
Sub project 2.1	Validating the monitoring programme
Sub project 2.2	Developing action thresholds
Sub project 2.3	BCA application rates and timing
Sub project 2.4	Crop protection gaps
Objective 3	**Upscaling BCAs**
Sub project 3.1	Matching BCA supply to demand
Sub project 3.2	Upscaling *Engytatus*
Objective 4	**Extension focus**
Sub project 4.1	Field days and communications
Sub project 4.2	The IPM programme
Sub project 4.3	Model system sites

Table 1. Project design

2.1 Objective 1 Scope and baselines

2.1.1 Sub project 1.1 Current practice

2.1.1.1 Introduction/background

There are a wide range of crop protection programmes in use across the greenhouse tomato sector. By providing a starting point or baseline, the project can measure the reduction of pesticide use and any increase in agroecological practice in its place.

The objective of this sub project was to document the current crop protection practice of glasshouse tomato production in NZ. This included crop protection programmes, both conventional and BCA based; monitoring programmes in use; economic thresholds being used, including pest:BCA ratios and release rates.

The deliverables for this sub project were:

- Annual report on NZ glasshouse tomato production, specifically current:
  - crop protection programmes;
  - monitoring programmes;
  - economic thresholds;
  - BCA release rates.

2.1.1.2 Materials and methods

Tomatoes NZ consulted and surveyed growers/managers to understand and document the crop protection practices that were in use at the start of the project. The same grower practices were reviewed annually in order to measure the changes and success of implementing agroecological practices.

At the conclusion of the 3-year project (September – October 2025), the same growers that took part in the survey at the start were consulted again and a report written.

2.1.1.3 Results

A report was written on the results of the pre project survey into the habits of growers in 2022. This is available (see appendix 3.1). Over the course of the project, spray diary data was requested annually and submitted to ALT anonymously for comparison. The post project survey report is also included (see appendix 3.2)

2.1.1.4 Discussion/Key Learnings

Growers are generally not that enthusiastic about sharing their spray diaries, even anonymously. For that reason, data from spray diaries did not prove to be a good way to gauge changes in practices.

Another limiting factor with spray diary information is that while it collects spraying events and what was being sprayed, once collated, the spraying events are unlikely to show why biological applications might still be required. This is due to the fact that not all greenhouse pests can be controlled with BCAs. For example, russet mites may require a different biological spray to caterpillars whereas previously what was sprayed for TPP might have controlled all other pests. As such, comparing the number of spray events isn't useful in showing a change in grower behaviour.

As a result, rather than using the data from spray diaries, changes in chemical use has been ascertained through anecdotal conversations with growers and via Bioforce data of customers' orders for BCAs and a post project survey.

Bioforce has seen an increase in the number of growers buying BCAs and asking for advice in using these. This has been captured by area of tomatoes being grown going from 12% of growers to 35% of growers (by area). More growers are waiting for Bioforce to increase their capacity to produce BCAs and will then also come on board. Another observation from Bioforce is that, in 2022, the 12% of growers using BCAs likely would not have completed an entire planting season without resorting to chemical inputs — but now, more of them are managing to do so regularly. This trend has been observed for both tomato growers that are new to using BCAs and existing growers who have increased their orders. These observations from Bioforce suggest these growers are more fully implementing IPM in their greenhouses.

Anecdotally, we are also hearing about greenhouse growers of crops other than tomatoes such as cucumbers, using parts of the IPM that are applicable to their growing operations.

In terms of the post project report, some main points are:

The resources produced are useful and sufficient to start on an IPM journey

- Where growers have chosen to use IPM, chemical use has reduced and most importantly, chemicals are no longer the first option that the growers surveyed reach for
- The research and trials have been helpful
- *E. nicotianae* as a predator has helped to reduce the number of TPP but hasn't stopped the issue of liberibacter infection due to the impact this disease has, even with fewer psyllids

- Whitefly remains a significant pest for greenhouse tomato growers – more so than TPP
- Tolerance for pest numbers still differ between different growers
- There is still, and likely always be, some resistance to change amongst some growers but those who are motivated have the resources to do so as a result of the project
- Some issues still remain with the logistics around receiving BCAs and availability of BCAs.

2.1.1.5 Timeline/Budget

	Revised June 2022	Actual
Commence date	1 Sep 2021	1 Sep 2021
Conclude date	31 March 2022	1 Jul 2022
Budget cash	$10,000	$1,710
Budget in kind	0	

2.1.1.6 Conclusion

The main learnings from the current practices sub project are:

- Growers do not like sharing their pest control practices unless this is mandated (e.g. due to export requirements). Establishing a formal overview of industry practices is almost impossible because of this.
- Pest control practices, including scouting, can be fairly well entrenched and it’s only when these are no longer working that growers might be willing to consider alternatives. Otherwise, growers appear to favour tried and tested methods that they are familiar with.
- Economic thresholds for growers differ – while one grower might tolerate a certain level of pests, another grower will find those levels unacceptable. IPM in the tomato greenhouse industry will only be a guide.
- Release rates are also tied to economic thresholds and therefore appear to differ between growers. While the release rates for predators would remain the same, in high pressure times of year/seasons, more predators would be required and some growers may question this as costs would inevitably rise.

2.1.2 Sub project 1.2 Pesticide side effects

2.1.2.1 Introduction/background

As part of the project, growers needed to understand that if they introduce BCAs but then decide to also use chemical spray applications, what the effect of this decision will be. For example, if the grower invests in a BCA programme which primarily includes the mirid bug *Engytatus* to control greenhouse whitefly but then wants to apply a product containing the active ingredient pirimicarb to control an outbreak of aphids, they need to be able to quickly check what the effect the product will have on their BCA population. The aim was to produce a grower friendly resource to support crop protection decision making in the greenhouse.

2.1.2.2 Materials and methods

Data collection for the development of the resources began with a review of current knowledge of the impact to similar BCAs subjected to the same active ingredients. Summary data of this review can be found in the references section (see appendix 1.1). This data was then overlayed with the International Institute of Biological Control (IOBC) database to correlate efficacy which was filtered to remove any chemistry that was unavailable to NZ growers. Of the remaining results, Bioforce completed in-house confirmation of side effects of the chemicals[3] deemed to be the most likely candidates recommended or selected by growers for use in the greenhouse.

2.1.2.3 Results

The information gathered needed to be user friendly as a quick reference guide for growers and was included in the New Zealand Residue Compliance Information for Fresh Greenhouse Tomatoes 2025 booklet. Two posters for easy viewing in the greenhouse were also developed (see appendix 4). TomatoesNZ will reproduce these documents annually allowing room for updates to be included if required.

2.1.2.4 Discussion/Key Learnings

Individual growers and growing operations have different controls and mindsets for controlling the pests that they see in their greenhouses as well as contrasting tolerance levels for those pests. The "zero pest" mindset continues to be one of the major challenges to establishing an IPM program. Educating growers so that they learn BCA use will mean not just reaching for their usual spray products but first checking the active ingredients and then looking at the guide, or contacting their BCA supplier, will always take time.

During the project, there were some anecdotal stories of some growers saying that BCAs don't work. When further investigations were made, it appeared to be a lack of understanding about the effect of chemicals applied at different stages of the growing process that were interfering with the ability of BCAs to establish. In some examples it was the residue of chemistry applied at the nursery stage, so this also needs to be considered. To address this, a workshop was organised for the group of growers who appeared to share this view. In addition, key messages about chemical use have been included in both written and workshop materials.

2.1.2.5 Timeline/Budget

	Budget Revised June 2022	**Actual**
Commence date	1 Sep 2021	Feb 23
Conclude date	1 Oct 2021	Sep 2024
Cash	$10,000	$5,000
In kind		

2.1.2.6 Conclusion

The education of growers in using BCAs as part of an IPM program will be ongoing. If a grower spends money on BCAs only to kill them with a chemical application, this will not have a positive effect on the grower wanting to continue using the IPM approach. Key messages around this will need to be repeated to change grower behaviour.

2.1.3 Sub project 1.3 Crop economics

2.1.3.1 Introduction/background

Any project that involves a new way of growing, will always have growers wanting to know 'at what cost?' It was necessary to provide growers an idea of what costs might be involved in changing to an

[3] To confirm the side effects of the chemicals, 10 petri dishes were prepared each containing 20 adult predators at 1-3 day emergence. Five petri dishes were sprayed with the label rate of chemical being checked, until run off. The other five petri dishes acted as a control and were sprayed with distilled water. The samples were checked at 24 hour intervals for five days under a binocular microscope and the results observed compared to the available data.

IPM programme from what they are currently doing. This includes having to benchmark the crop economics of the industry at the start of the project in 2022.

2.1.3.2 Materials and methods

Factors that needed to be considered to calculate crop economics:

- the cost per hectare of spraying according to the pre IPM methods (see graph 2 and table 1 on labour costs below)
- the total weight of tomatoes per hectare that were being produced with pre IPM methods; and (see graph 1 below)
- the percentage of grade TAG 1 and 2 tomatoes being produced under the pre IPM methods.

This data was collected over one season from a single greenhouse, comparing a crop managed under an agrichemical-based crop protection programme (referred to as the 'control crop') with a crop managed using IPM (referred to as the 'trial crop'), both grown in the same environment

2.1.3.3 Results

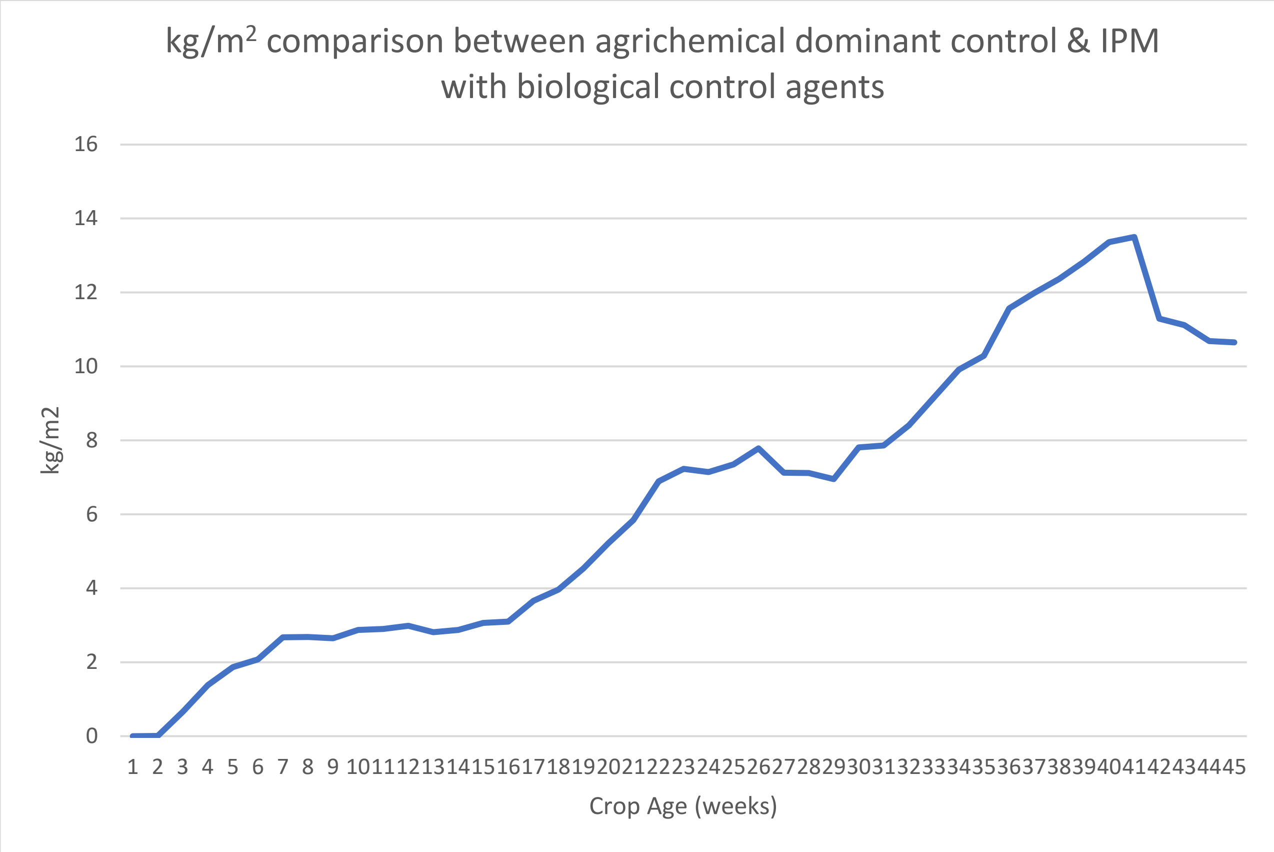
This crop economics report is a comparison between a crop using biological control agents and selective agrichemicals consistent with integrated pest management (IPM) (trial crop) and a crop which used agrichemicals as its core control option (control crop).

In the first season the grower used IPM compatible agrichemical control on the trial crop but the number of whitefly reached an unsustainable level. It was only due to a strong intervention with biological plant soap when the crop was weak with reduced leaf length, that the whitefly levels reduced, and the tomato trial crop was saved. In the second season the grower used biological control agents from the start and used selective agrichemicals sparingly on the trial crop. This resulted in a much more controlled tomato crop with very low levels of whitefly (see graph 3 below).

Production

Graph 1 shows a difference of 10.6kg/m^2 production variance between the two crops

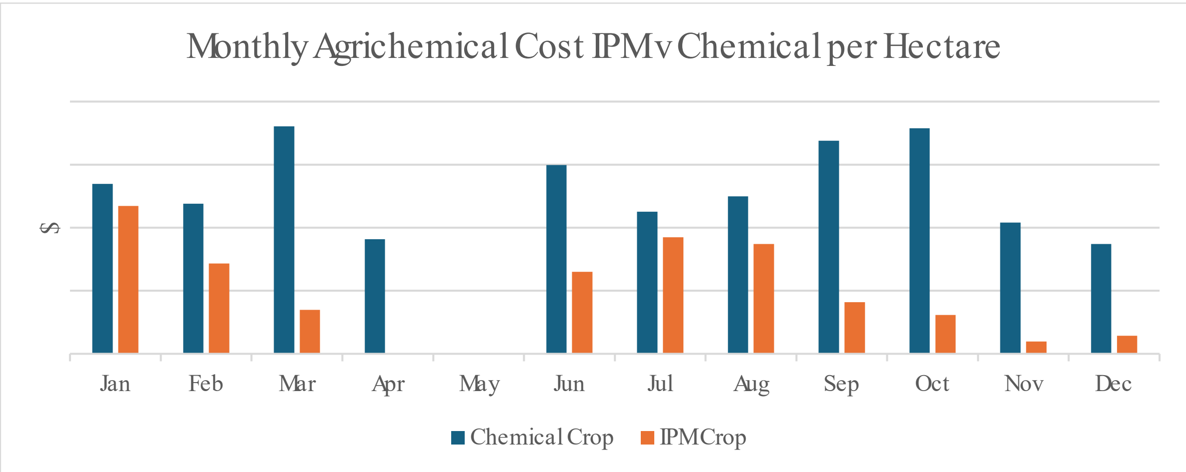
For the purpose of this report, \$2 per kg is used as the return to grower. For 1 hectare this equates to an increase in revenue of two x 10.65kg x 10,000m^2 which gives an increased return of \$213,000 per hectare.



Graph 1. Production – the difference in volume of crop produced

Agrichemical costs

Graph 2 shows that agrichemical spray costs were reduced by 61%. This included all agrichemicals, including fungicides.



Graph 2 Agrichemical costs (shown as multiples of $500)

Biological Control Agent Costs

The cost for the biological control agents came to $12,068 per hectare. This included two releases of *Engytatus* and weekly releases of *Encarsia* at recommended rates in response to scouting results.

Comparison of IPM and Spray Control

The combination of biological control agents and agrichemical use added 18% more cost per hectare compared to just using agrichemicals alone.

Labour

	Agrichemical Crop	IPM Crop
Scouting Hours per Hectare (42 weeks)	**42**	**84**
Releasing *Encarsia* Hours per Hectare (42 weeks)	**0**	**63**
***De-leafing Hours per Hectare (36 weeks)**	**2160**	**1476**
Spraying Hours per Hectare	**75 (weekly sprays)**	**25 (monthly sprays)**
Annual Crop Rotation Clean Up De-leafing Pickup	**0**	**278**
Total Hours	**2277**	**1926**
Total Cost ($25 per hour)	**$56,925**	**$48,150**

Table 2 Labour costs

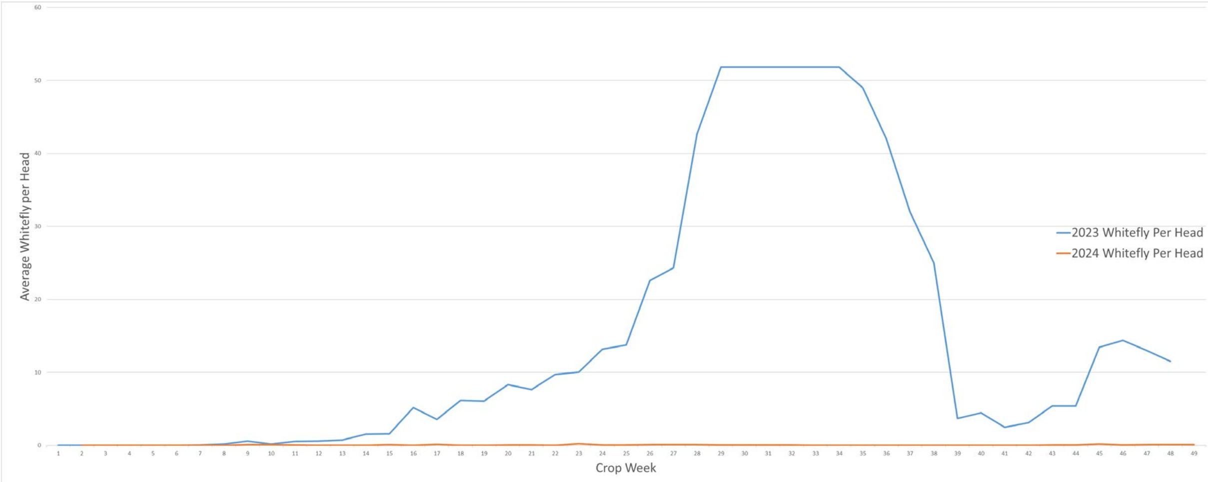
*Where de-leafed plant material is placed at the time of de-leafing has an impact on labour spend. There are two options for leaf material; 1. remove while de-leafing, 2.drop on the floor and remove at the end of the crop. Option 1 provides no opportunity for *Encarsia* to hatch back into the glasshouse.

Option 1 (remove de-leafing – 3 leaves): 50 hours per hectare per week + 10 hours for logistics (forklift with bins)

Option 2 (drop on floor and pick up at the end of the crop): 41 hours per hectare per week + end of crop clean-up costs using Wettering Mat machine 278 hours

Quality

The grower reported an increase in quality in the IPM crop. However, quality is not a fixed metric as it can change with market variability, including the quantity of fruit at that quality. For the purposes of this report, it is not reliable data.



Graph 3. Number of whitefly per crop week before (2023) and after (2024) using the IPM programme.

2.1.3.4 Discussion/Key Learnings

While this one growing operation was able to turnaround a poor conventional chemical spraying season and then implement a full IPM programme the following season with economic gains, more seasons of growing with an IPM approach are required to understand if these economic gains can be repeated. Even for this operation there are many variables which could make the economic gains differ from one season to the next.

2.1.3.5 Timeline/Budget

	Budget Revised June 2022	**Actual**	**Comments**
Commence date		Sep 21	
Conclude date		Mar 22	
Cash	0	0	Budget and activity removed in reset
In kind			All activity in this subproject was provided as in-kind

2.1.3.6 Conclusion

There are a range of grower expectations when it comes to crop economics. Additionally, pest control is but one factor in determining crop profitability.

There will always be caveats and limitations to providing crop economics from commercial settings. Some examples of this include different factors e.g. climate variations between growing seasons making it hard to compare one year with another; pest pressure from one year to the next differing for reasons beyond control method; the growing (previous and new) procedures at one site perhaps not being the same at a different growing operation; growers constantly trialling and introducing different tomato varieties. Some of these factors are more or less susceptible to pest pressure.

However, even with these known limitations, the data produced in this project provides growers an indication of what could be achieved by changing their control methods for pests.

2.2 Objective 2 Filling knowledge gaps

2.2.1 Sub project 2.1 Validating the monitoring programme

2.2.1.1 Introduction/background

The validity of determining BCA application rates, depends on monitoring across all sites following a standardised protocol. Lincoln University was tasked with producing a statistically verified method for determining the level of infestation of whitefly (See appendix 1 for reference, Veronesi & Godsoe). The conclusion of this document was that for statistical validity, a minimum of 50 plants should be observed. Less than this was not adequate and more was not significantly more accurate.

The initial conversations indicated that most growers were following a one row per truss per week monitoring protocol. This is a relic of the potato spindle tuber viroid (PSTVd) related export requirements.

During the course of this project, it was identified that the monitoring protocol required some adjustments as the key pests have short lifecycles. It was determined that an ideal scouting protocol would be to observe all plants every 14 days in order to observe early-stage infestations. This led to a protocol requiring the inspection of alternate rows weekly with an emphasis on spotting the signs of pests rather than less frequent observations at a higher level of detail. Although this level of observation far exceeds the minimum requirements for accuracy established by Lincoln University, the intention was to observe the pests before they became established throughout the greenhouse. It should also be noted that as per normal industry protocols, thorough plant inspections are not carried out on every plant, the emphasis is on noticing the signs of pests at a quick glance as this is more achievable for growers in terms of the time required. Thorough inspections are only carried out on a random plant approximately every 10m.

2.2.1.2 Materials and methods

The monitoring programme/scouting protocol was distributed to the scouts at all sites and explained in person. It quickly became apparent that the size of the operation meant that different scouting methods would be required depending on the size of the commercial operation:

- For the large growers who employed dedicated scouts, the scouting protocol identified by Lincoln University could be implemented.
- For the smaller growing operations where there might not be any employees, their own informal monitoring protocols were used.

In smaller operations, the owner tended to walk the crop more regularly, so noticing changes becomes an informal scouting method. While the contractor tried to change these habits, it became apparent over time that both the Lincoln University and informal method were valid and it was decided by the project team to accommodate both the formal scouting at larger operations and the informal scouting at smaller operations.

2.2.1.3 Results

The Lincoln University scouting protocol was able to be validated by contracting Agriquality scouts for a three month period at one trial house that had a dedicated scout employed. The observations of the contractor were consistent with those of the inhouse scouts.

The new scouting protocol/monitoring programme of more frequent observations allows for the early detection of any pest incursion and this works well for those with a dedicated scout.

In smaller operations, a formalised scouting programme is difficult to implement. The grower/owner is scouting in an informal way by regularly walking and monitoring their crops. This also allows for more frequent observations and earlier detections of pests.

2.2.1.4 Discussion/Key Learnings

As discussed above, the standard monitoring programme set out by Lincoln University could not be established in all trial sites and it was decided this was acceptable because an IPM programme is only ever a guide for growers to adopt and adapt to their specific growing situation. However, the standard monitoring programme was able to be validated and can be confidently implemented into larger growing operations.

The informal monitoring programmes from smaller growing operations provide actionable results and are easier for smaller operators to implement.

As scouting has become less about the overall whitefly population, and more focused on the early detection of pest incursions, the observations of the scouts have developed into noticing any unusual symptoms and investigating them. As more growers adopt IPM they begin to observe pests that were previously supressed by the whitefly spray program. This means scouts need to be better informed on the pests they are likely to observe. This is aided by the series of "Action cards" which the project has produced (see appendix 5).

2.2.1.5 Timeline/Budget

	Budget Revised June 2022	**Actual**
Commence date		Sep 21
Conclude date		Oct 22
Cash	20,000	20,000
In kind		

2.2.1.6 Conclusion

Overall, the scouting protocol that a tomato grower adopts will depend on the size of the operation because the number of plants and resources available will determine what will work best.

An IPM programme is a guide rather than a strict manual that should be adhered to. The guide needs to be flexible enough for growers to be able to adapt it to what suits them, as observed in this subproject. The trial found that the focus should be on encouraging growers to scout regularly, whether that's following an established protocol of observing a set number of rows per week or observing the full crop more regularly.

2.2.2 Sub project 2.2 Developing Current Thresholds

2.2.2.1 Introduction/background

Historically, growers have monitored the greenhouse pest populations and when they reach the grower's tolerance a chemical treatment has been applied. Each grower's tolerance for pests is highly variable, but commonly a zero-pest tolerance, or perhaps any observation of a population of over five pests per plant, was used as a threshold. The goal of developing a guide for an IPM approach required the development of pest thresholds based on data rather than thresholds that were previously based on largely instinctive rules. These were then developed into a set of guidelines appropriate to the introduction of a BCA based control program.

The observations of the current practices of whitefly control and their outcomes suggested that whitefly populations were established early and began to escalate nearly exponentially at approximately 10-12 weeks after planting. Introducing BCAs once the pests were established had little effect, potentially due to the grower beginning a regular spray program. The approach was changed to one of introducing the BCAs immediately after planting and observing the result.

TPP populations were also monitored. The presence/absence of the bacteria like organism *Candidatus liberibacter solanacearum* (referred to from here as 'liberibacter') is a key determinant of the grower's response. Liberibacter is rapidly spread by TPP and leads to plant death. Some populations do not carry liberibacter so the TPP damage is generally localised and minor. Where the population carries liberibacter the outcome is more serious, so the grower needs to respond in a more aggressive manner. We investigated two BCAs, *E. nicotianae* in a banker plant arrangement (in several configurations) and *Buchananiella whitei* as a spot treatment.

2.2.2.2 Materials and methods

Both whitefly and TPP populations were monitored at all trial sites by either dedicated crop scouts or the site owner/grower. The protocol was to scout every second row on a weekly basis resulting in all plants being observed every two weeks. Observations were made of whitefly population and percentage parasitism as an indicator of *Encarsia* parasitism levels. TPP presence was also recorded along with the presence of the TPP predators used at that site, either *E. nicotianae* or *B. whitei.*

It is important to note that these observations were made in fully operational commercial greenhouse sites with financial interests at stake, not dedicated research sites. As such, the introduction rates of the BCAs to control the two pests, needed to be tailored to the tolerance levels of the individual trial sites.

2.2.2.2.1 E. formosa and Whitefly.

Initially at some sites *E. formosa* was introduced at curative rates later in the crop into established whitefly populations. Later in the crop refers to not immediately after planting, rather waiting for a visible whitefly population to establish in the first 1-4 months of the crop. These rates varied but were up to 50 *E. formosa* per m^2 without regaining control of the whitefly.

At other sites *E. formosa* was introduced at a low rate (1-3/m^2) immediately after planting.

2.2.2.2.1 E. nicotianae and TPP

International observations of various species of mirid bug used as a BCA in glasshouse tomatoes demonstrates that the most efficient and economical way to introduce these predators is through the use of banker plants (See reference Bresch, C. et al).

The term banker plant is used when a plant is introduced as a 'home base' to provide a food source (either directly, or due to harbouring food bug species) to breed a colony of BCAs. These BCAs are then distributed, independently or assisted, throughout the crop as pest species invade.

In this case, tobacco plants were used as banker plants. This species was selected because *E. nicotianae* can complete its lifecycle on it.

The standard of one plant per 1000 square meters was used as a starting point, in an attempt to duplicate the outcomes. Initially the spread of the predator was very limited, so it was decided to physically remove parts of the banker plants and distribute them throughout the greenhouse. This introduction protocol was repeated across multiple sites over the course of the project.

2.2.2.1 B. whitei and TPP.

B. whitei cannot complete its lifecycle without prey and therefore can only be introduced in the presence of prey. This BCA was introduced to the project to determine if it was a BCA which could be applied directly to a TPP infested plant and demonstrate a curative effect.

It was applied to recent infestations at an initial rate of 2.5ml (approximately five adults) and 5ml, approximately 10 adult *B.whitei*, per infested leaf per week/2 weeks.

2.2.2.3 Results

In the first year *E. nicotianae* was introduced through tobacco banker plants with an initial release to colonise the banker plants that equated to 0.1 adults per greenhouse m^2. The results were disappointing, so this initial colonisation release was increased to 0.3 adults per greenhouse m^2 and immediately proved to be more successful.

Across five trials (three separate sites), introducing *E. formosa* the week after planting in combination with *E. nicotianae* on banker plants at row ends demonstrated excellent control of the whitefly population.

The *E. nicotianae* were observed to limit their hunting to an area with a radius of approximately 5m from the banker plant. To address this, fragments of the banker (leaf or flower) were distributed along the rows when whitefly was observed. This resulted in the rapid control of whitefly to an acceptable level.

After the limited hunting radius was observed it was speculated that distributing the banker plants throughout the crop may achieve a better result. Unfortunately, the banker plants were rapidly outgrown (vertical height) by the tomato crop and lost in the rows.

The effect of the *E. nicotianae* on TPP was also observed. One trial site in a medium pressure area showed no TPP for three consecutive seasons. At the other sites TPP was observed, however the infestations were limited to small areas.

The spot application of *B. whitei* in a greenhouse from an area where the TPP population have historically never carried liberibacter was also tested. At this location the grower was treating infestations weekly as they were observed. Initial results were slow and limited, so the release rate was increased from five adults per infested leaf to 10. This led to overnight eradication of all visible lifecycle stages. The frequency of treatment was increased to a release every 14 days as control improved.

The spot application of *B. whitei* successfully significantly delayed and/or removed any requirement for any agrichemical application.

2.2.2.4 Discussion/Key Learnings

E. Formosa

In a crop with an established whitefly population, spray intervention with physical mode of action sprays (e.g. PS1 plant soap) and a good spray technique, was able to reduce the whitefly pressure sufficiently to begin a successful *E.formosa* program. However, this required considerable cost and effort.

In the crops where *E. formosa* was released immediately after planting at low rates (1-3 *E. formosa*/m^2) good control was established throughout the season.

It was decided that moving forward, it was necessary to begin with a low rate (1-3/m^2) introduction of *E.formosa* immediately from planting. The low rates being used at clean sites, the higher rate if there is a whitefly history or local pressure. This slowed the progression of whitefly infestation to a sufficient degree that by modifying the weekly release rates, full control of whitefly was possible. These rates were repeated across all sites. Please see appendix 5 for the whitefly decision tree.

E. nicotianae

Releasing the *E. nicotianae* through a banker plant approach with a density of one banker per 1000m^2 and breaking parts of the plant off and delivering them to any whitefly "hotspots" down the rows resulted in consistent control of whitefly.

There was a total absence of TPP from sites that historically had multiple infestations in any year. There were also plants showing positive liberibacter tests in greenhouses where not a single TPP had been observed. This is likely because it only takes a 'hot' TPP five minutes of feeding on a tomato plant to infect it with liberibacter. The lack of an observable population of TPP suggests that they were prevented from establishing, likely by *E. nicotianae* moving in to predate the TPP.

B. whitei
The introduction of *B. whitei* into newly observed psyllid infested plants resulted in the rapid removal of all juvenile stages of TPP in 1-2 days.

Initially the BCA was supplied at a rate of five adults per infected leaf on a weekly basis. Due to the slow results this was increased to 10 *B. whitei* adults per infested leaf per week, however, control was so successful that the supply was reduced to once every two weeks.

In the trial site this was sufficient to delay the requirement for chemical intervention for 2-3 months in consecutive years compared to historical information.

Application thresholds are a concept with its origins in chemical application. In a BCA based system it appears that the idea of thresholds is largely obsolete as the earlier the predators are present the more successful the control. The limiting factor to BCA control appears to be the BCA:pest ratio. The lowest number of pests is at the very beginning of the season and BCAs are very effective. Late introductions are seldom successful because once a pest population is large, a favourable BCA:pest ratio is difficult to achieve.

2.2.2.5 Timeline/Budget

	Budget Revised June 2022	**Actual**
Commence date		Oct 22
Conclude date		Mar 25
Cash	85,008	102,422
In kind		

2.2.2.6 Conclusion

All BCAs, no matter which species are used, should be introduced to the crop as soon after planting as possible to give the IPM programme the greatest chance of success. When this is done, the concept of pest thresholds is largely obsolete compared to when growing with agrichemicals.

2.2.3 Sub project 2.3 BCA application rates and timing

2.2.3.1 Introduction/background

In order to deliver tomato growers with a complete IPM program to work with, a series of guidelines around the week-to-week management decisions that need to be made needed to be developed.

2.2.3.2 Materials and methods

Data on the observations of monitoring each pest was collected weekly from all the trial sites throughout the project to aid in decision making around the implementation of an IPM programme. Day to day management of the programme was in consultation with Bioforce and general planning addressed at monthly meetings.

2.2.3.3 Results

In order to develop a simple set of rules, all the monitoring results of the sites in the trial programme were analysed and the processes that demonstrated the best results were identified.

The *E. formosa* feed on 2nd instar larvae and parasitise 3rd and 4th instar. This equates to about 350 larvae in their lifetime compared to a female whitefly laying about 100 eggs in her lifetime. The lifecycles are temperature dependent, but from approximately 12°C, the *E. formosa* lifecycle is shorter. As there are generally 2-3 plants per m^2, and a single *E. formosa* kills approximately three times as many juvenile whitefly as an adult whitefly produces, the rule of thumb of 1 *E. formosa* /m^2 x average number of whitefly per head was established.

This process ultimately led to the development of the grower resource, the 'Whitefly decision-making tree' (see appendix 5). This was then applied to all trial sites the following season to confirm its efficacy.

The use of these guidelines has reinforced the success of early introduction of predator programmes. One crop was even recovered, after a failed traditional approach, through repeating the 20+ whitefly per plant head step until the population was controlled to a level where the BCAs could cope.

Another result of the trial was an observation that production and quality improved when pests are controlled within an IPM program. See 2.1.3 crop economics for more information.

2.2.3.4 Discussion/Key Learnings

As discussed above, the key to effective BCA application is early introduction.

It is important to monitor the whitefly population, disperse *E. nicotianae*, and be ready to apply a soft corrective spray if the population of whitefly exceeds the acceptable range as highlighted in the whitefly decision tree.

In the crops that were part of the trial greenhouses, we commonly saw populations of whitefly stable at well below five whitefly per plant, with over 90% levels of *E. formosa* parasitism on any eggs observed.

Throughout the project it became apparent that in a BCA based system the adult whitefly population threshold for visible damage was considerably extended. This is believed to be due to the lower population of juveniles present, due to the level of predation of the BCAs as the juveniles secrete a sugary substance known as "honeydew" that is the primary source of fruit damage.

Challenges that were encountered included a lack of acceptance of even low whitefly populations (zero pest tolerance mindset), lack of understanding around what/when/how to apply a corrective spray, and the presence of new pests that were otherwise supressed by the constant whitefly spray control system.

The biggest challenge was overcoming some growers' reluctance to spend money on a pest that is not present. The more typical scenario is for growers to solve problems that are already established which is too late when following an IPM approach. This mindset was addressed with targeted messaging that introducing BCAs at the same time as planting seedlings can be considered an insurance policy to stop pest pressure from hopefully building up beyond desired thresholds. As with all new learnings, repetition of key messages will need to continue for some time until the new practices are established as 'normal'.

2.2.3.5 Timeline/Budget

	Budget Revised June 2022	Actual
Commence date		Oct 22
Conclude date		Mar 25
Cash	113,384	125,010
In kind		

2.2.3.6 Conclusion

Results from the BCA application rates and timings subproject reinforces the conclusion from the subproject investigating pest thresholds (sub project 2.2). The early introduction of predators, coupled with the ongoing adjustment of introduction rates and other control measures according to what is observed during scouting and will lead to improved pest control. This approach is laid out in the decision tree resource for whitefly control (see appendix 5).

2.2.4 Sub project Crop protection gaps

2.2.4.1 Introduction/background

Throughout the trials it was highlighted that there were other previously unobserved pests which became an issue if 'hard' chemicals weren't being applied. The term 'hard chemicals' refers to non-target specific, often highly residual chemicals that are not compatible with an IPM approach but favoured in a direct chemical approach. This necessitated additional sub projects to be undertaken to ensure a robust IPM programme.

Additional sub-projects as a result of this project are:

1. Whitefly reverse decay trial
2. Spray technique
3. Russet mite reverse decay trial (this project got underway after the completion of this trial in September 2025)

The whitefly reverse decal trial

This trial was part of the A Lighter Touch's minor use trial programme. It was undertaken because there could be times when growers need to use agrichemicals to control whitefly such as before beneficial insects are introduced. A number of products make a claim for whitefly for off label use with greenhouse tomatoes. It was important for growers to know what the residues of these products is so that they can make sure that crops that have been sprayed with these products comply with the minimum residue limits. In an IPM setting, it's also important to understand when BCAs might be introduced into the crop to control whitefly after residues have dissipated.

The products that were part of this trial were:

- Benevia
- Mainman
- Movento OD
- Calypso

These products were chosen because they are known to be used by growers for whitefly control. These were applied to a crop of cherry tomatoes in a greenhouse at the maximum recommended application rate. Leaf samples were taken at regular intervals from Day 3 post application to Day 35.

A technote for growers was produced following the results of this trial (see appendix 6).

Essentially when applied at the maximum rate, Benevia has a residue until Day 28, Mainman, Movento OD and Calypso until Day 35.

Several factors will influence the residues in an individual greenhouse including aspects like spray technique, time of year/sunlight, how old the product is, and getting the agrichemical:water ratio correct.

The MRLs suggested in the technote were a surprise for growers (longer than anticipated) and is useful for them to be aware of.

Spray technique

During the first two years of the project, it was noted that growers don't always have a good set up and knowledge around sprayers. Spray corrections are within the scope of an IPM programme, as these can be required to control hot spots. Due to the prevalence of chemical resistance, the project recommendations have been focused around physical mode of action chemistry. This type of spray has no translaminar/systemic/ingested activity, the spray needs to be applied directly to the pest. This has highlighted an industry weakness around the configuration and maintenance requirements of spraying equipment.

As with the other resources for this project, it was important to produce something that was both in a written format and as a practical video. We also held two in-person demonstration workshops. The printed resource 'How to Set Up Your Sprayer' (see appendix 6) needed to be based on a photo of a typical spray set up so that growers could use it to identify the different parts of the machine. This also takes into consideration that long pieces of writing are not always suitable for growers who have English as a second language.

The spray workshops highlighted that spraying techniques amongst growers vary considerably and that this is an area that needs ongoing education.

The use of water sensitive papers allows growers to see exactly where the spray is depositing on the crop and is a good way for growers to investigate if their sprayers are set up correctly. In both workshops, the sprayer set ups growers were using could be improved to more effectively target the pest.

As numbers at the practical workshop were limited and to have information that could continue to be referred to, a video capturing some of the main tips was also made.

One of the learnings from this exercise was that growers use a multitude of different spray set ups from robotic to handheld. The practical workshop provided everyone with some tips and tricks for improving their technique but would have been better if either robotic or handheld had been more thoroughly covered in one session.

Russet mite reverse decay trial

As this project was not underway before the end of this project, it can't be included in any detail. Results however will be added to the TNZ website main IPM page www.tomatoesnz.co.nz/ipm once ready and shared with growers via the NZGrower magazine, ALT newsletter and in workshops.

2.2.4.2 Timeline/Budget

	Budget Revised June 2022	Actual	Comments
Commence date		Sep 21	
Conclude date		Mar 25	
Cash	0	0	No cash budget for this activity
In kind			

2.3 Objective 3 Upscaling BCAs

2.3.1 Sub project Matching BCA supply to demand

2.3.1.1 Introduction/background

Historically one of the major concerns over the use of BCAs has been the supply of sufficient amounts of BCAs to growers. This project provided the opportunity to understand the actual supply and demand of BCAs in an IPM programme.

2.3.1.2 Materials and methods

Conversations were undertaken with various growers within the project regarding the start time of BCA introductions, quantities released, and the cost of producing the predators.

2.3.1.3 Results

Growers are generally reluctant to begin early releases of BCAs. There is a mindset around curative action rather than preventative action. This leads to a situation where BCAs are introduced late, when pests are established. At this time the required quantities of BCAs are very high. If the supplier cannot meet demand the growers give up and return to their chemical approach.

The production of a BCA is time consuming and expensive. To produce an *E. formosa* egg requires the establishment of a host plant, this must then be infested with whitefly, the whitefly multiply and proliferate. *E. formosa* are then introduced, they parasitise the juvenile whitefly which then pupate and are harvested. This process requires a minimum of two months. The produced eggs then have a short shelf life.

2.3.1.4 Discussion/Key Learnings

Once the growers understood the long lead time and high cost associated with BCA production, they agreed that a long-term purchase contract that ensured supply would reduce the risk to the BCA producer and remove the constraints on BCA availability.

The other key factor was the understanding that relatively small weekly releases from the beginning of the crop reduced the requirement for very large BCA orders and kept the pests under better control.

This has led to a smooth supply of BCAs across the sites and, in many cases, complete management of pests. It has also removed the sudden requirement for very large numbers of predators that was previously the issue.

There have been instances where the logistics of supplying growers that are distant from the BCA producers has interrupted the growers' IPM programme. Provision for this needs to be considered.

2.3.1.5 Timeline/Budget

	Budget Revised June 2022	Actual
Commence date		Sep 21
Conclude date		Dec 24
Cash	5,000	832
In kind		

2.3.1.6 Conclusion

Once everybody involved in the process was communicating and aware of the risk and time constraints around BCA production it was relatively simple to align production capacity with demand.

2.3.2 Upscaling *Engytatus Nicotianae*

This section was removed from the project in 2022 and this variation subsequently approved by PGG after discussion with the project team. It was agreed that Bioforce was best placed to complete this activity commercially as there was a risk as to who would own the IP at the end of the subproject. This risk was mitigated by Bioforce undertaking this work.

2.4 Objective 4 Extension focus

2.4.1 Field days and communications

2.4.1.1 Introduction/background

Throughout the project timeframe, it has been important to keep stakeholders informed. The stakeholders can be seen as being those funding the project, namely:

1. Growers who pay the TomatoesNZ levy provided to the ALT programme. The levy-paying growers also meant that the TomatoesNZ board, who make decisions about how levies are spent and are answerable to the levy payers also needed to be kept informed. Finally, the growers also needed to be brought along on the journey for education purposes if the IPM methods that were found to have benefit for pest control were going to be adopted by other growers outside of the trial greenhouses.
2. Ministry for Primary Industries (MPI) through the Sustainable Food & Fibre Futures (SFFF) Fund. ALT is a partnership programme between industry and government. The ALT team report on a quarterly basis in the first instance to the Programme's Industry Stakeholder Advisory Group (ISAG) and then to the Programme Governance Group (PGG). The ISAG comprises of representatives of all participating Product Groups. As a collaboration across the whole of the horticulture and arable sectors there is much cross over benefit where crop protection issues and solutions in common are shared and addressed collectively. The PGG includes representatives from the ISAG and MPI's Investment Programmes team. MPI invests in New Zealand's primary industries, primarily focusing on the food and fibre sector, with a goal of doubling the value of exports by 2034. MPI's investment programmes are

aimed at enabling businesses to innovate, grow, and trade, and is structured through various funding and support programmes such as the SFFF Fund. MPI are therefore very interested in how their investments are performing: how their programme partners are benefiting from project work, how this helps the primary industries collectively, and how programme outcomes flow through to the national economy.

2.4.1.2 Materials and methods

Growers generally learn best by seeing principles in action. Unfortunately, due to biosecurity issues with tomato plants, it has not been possible to take growers into the trial greenhouses. To overcome this issue, it was decided early on that a series of short videos should be developed that would support written materials. These resources would be introduced at in-person and online workshops.

2.4.1.3 Results

The following videos have been produced as part of this project and are all available at: https://www.youtube.com/@TomatoesNZ

- Whitefly control as part of IPM
- How to use *Engytatus nicotianae*
- How to use *Encarsia formosa*
- How to scout
- Tips on dealing with spot pests
- Practical tips for spraying

The following written resources have been developed as part of this project:

- Seven action cards are available to download at : https://www.tomatoesnz.co.nz/ipm/:
- Psyllid
- Aphids
- Caterpillars
- Russet Mite
- Sciarid Flies
- How to scout
- Thrips (and Tomato Spotted Wilt Virus)
- A whitefly decision tree.

The following meetings have occurred as part of the extension and communications plan from the project:

- May 2023 – Seth Laarakkers delivered a project update to the TNZ board meeting, Auckland
- August 2023 – Lex Dillon delivered two project updates at the HortNZ conference as part of the Vegetable Sessions and also the ALT programme, Christchurch
- September 2023 – Seth Laarakkers delivered a workshop for growers Pukekohe, including the first video and whitefly decision tree
- Feb 2024 – Lex Dillon delivered a project update to the TNZ board, Auckland
- April 2024 – Lex Dillon delivered a project update to growers as part of the Vegetables NZ and VR&I roadshow, Pukekohe
- May 2024 – Lex Dillon delivered a project update to growers as part of the Vegetables NZ and VR&I roadshow, Nelson
- June 2024 – Lex Dillon and Chris Thompson delivered a '101' into using beneficial insects to Korean Growers, Pukekohe

- August 2024 – Lex Dillon delivered a 'lessons learnt' update to growers as part of the TomatoesNZ mini conference, also showing new videos and introducing the printed IPM guide, Pukekohe and online
- March 2025 – Lex Dillon delivered a project update to the TNZ board, Auckland
- June 2025 – Lex Dillon presented learnings from the project at a TPP/liberibacter workshop for tomato and potato growers thanks to funding from VICE. He was joined by Bioeconomy Science Institute - Plant & Food Research scientists presenting their findings on TPP in potato crops, Pukekohe and online
- August 2025 – Lex Dillon to delivered a presentation at New Zealand Plant Protection Society Symposium, Christchurch
- August 2025 – Lex Dillon delivered a project update to attendees at the HortNZ conference, Wellington
- August 2025 - Lex Dillon delivered a project update to attendees at the Strawberry Growers NZ conference, Auckland

The following articles have been written about this project:

- *Native predators being trialled in greenhouse tomatoes*, ALT newsletter, April, 2023
- *Native predators being trialled in greenhouse tomatoes,* NZ Grower, June 2023
- *Whitefly workshop a must for tomato growers*, ALT newsletter, August 2023
- *New grower resources for whitefly management shared,* ALT newsletter, September 2023
- *Biocontrol project in tomatoes shows success*, ALT newsletter, March 2024
- *Biocontrol project in tomatoes shows success,* NZ Grower, April 2024
- *New grower resources for tomatoes IPM*, ALT newsletter, August 2024
- *BCA knowledge shared with growers*, ALT newsletter, October 2024
- *Revitalising IPM in greenhouse tomatoes*, ALT newsletter, November 2024
- *Commericalising Biologicals in Large Scale Greenhouses, NZGrower magazine, July 2025*

2.4.1.4 Discussion/Key Learnings

With a multi-year project the learnings are ongoing and growers need to be taken on the journey with regular extension updates offered in a number of formats to suit different growers. Adoption will never be immediate and some growers will choose to not make any changes but letting growers know about findings is important so they can see what the options are as well as seeing how a significant proportion of their levy money has been spent.

Growers learn in different ways and at their own pace. Appetite for risk will also be different for different growers.

2.4.1.5 Timeline/Budget

	Budget Revised June 2022	**Actual**
Commence date		Apr 22
Conclude date		Mar 25
Cash	24,000	19,402
In kind		

2.4.1.6 Conclusion

Extension will continue after this project has been completed. It needs to be regular and offered in different formats. The advantage of the videos is that they are a reference for growers to continue learning from when they're ready and have time. This coupled with a local BCA supplier who has knowledgeable staff, are integral for growers wanting to make a change to their practices for controlling pests. Having someone 'hold their hand' is extremely important in encouraging change.

2.4.2 The IPM Programme

2.4.2.1 Introduction/background

The ultimate goal of the project was to provide the tomato growers of NZ with a complete IPM guide for the control of pests in the greenhouse.

This involved detailed management guides for the current key pests, whitefly and TPP, coupled with IPM friendly guides for other pests believed to become more prevalent as the whitefly spray intensity was decreased.

2.4.2.2 Materials and methods

The control of pests in all the trial sites was analysed each month and discussed at monthly project meetings. Fundamental IPM guides for whitefly and TPP were established, and as other pests (such as russet mite and caterpillar) became apparent, they were incorporated.

2.4.2.3 Results

The result has been the production of several grower resources (listed above). The primary resource produced has been the IPM Folder which in its printed form (available to all tomato growers), contains all the materials produced as part of this project. This is a living document containing information regarding the IPM control of all the common greenhouse tomato pests that continues to be updated as research is completed, and information comes to hand.

2.4.2.4 Discussion/Key Learnings

The key to IPM is the grower accepting that there will always be a pest:predator balance and the programme begins as the seeds for the new crop are propagated. Growers who commit to the approach are generally very satisfied. History has demonstrated that growers who attempt to begin the programme late or alternate between chemical and IPM struggle to succeed.

2.4.2.5 Timeline/Budget

	Budget Revised June 2022	**Actual**
Commence date		Mar 23
Conclude date		Jul 25
Cash	45,000	11,569
In kind		

2.4.2.6 Conclusion

An IPM guide has been produced that has been added to and edited as the learnings from each season have been adopted. This is now available on the TomatoesNZ website so that all resources are in one place. The work however has not finished and IPM will always be part of the work of TomatoesNZ, whether that is making changes to current knowledge or further developing practices for pests that have shown themselves to be an issue outside of TPP and whitefly.

2.4.3 Model System Sites

2.4.3.1 Introduction/background

The project required the selection of commercial trial greenhouses to test the laboratory-based findings of Emiliano Veronesi's initial work which had good success in controlling TPP with *E. nicotianae* and to act as sites to demonstrate to growers the techniques that were being trialled

2.4.3.2 Materials and methods

The first year of the trial was set at a Waikato production site where a 1-hectare trial was to occur in conjunction with a 2-hectare control. Unfortunately, there was a TPP incursion before the trial was established and commercial reality required a chemical intervention that meant the trial had to cease. After this it was felt that the project needed multiple trial greenhouses to act as an insurance policy to other unforeseen circumstances. A range of regions and planting cycles ensured there would always be crops available for comparison of IPM methods.

The other benefits of multiple trial sites are duplicated results (validity), insurance that other variables (e.g. grower attention, externally pest populations) were not responsible for outcomes, and first-hand proof of concept being visible in the sector. The multiple site approach also allowed the different strategies to be attempted simultaneously, decreasing the timeline required to produce the desired outcome.

There were also benefits of including growers of different sizes and in different parts of the country for demonstrating wider validity in the results.

2.4.3.3 Results

The result was eight different growing sites with seven greenhouses participating at any one time. This has given the project a good number of scenarios to work with and produced a good amount of data.

The most successful BCA combination utilised was *E. nicotianae*, introduced on tobacco banker plants, and *E. Formosa,* introduced as eggs fixed to cards. Initially a trial was completed at one growing site, where a glass wall separated plants produced under a traditional chemical approach with a trial of these two BCAs. The BCA combination provided complete whitefly control, where the chemical only compartment was severely infested. This successful outcome was duplicated four times across three trial sites (zero applications of pesticide for whitefly control). At one of these trial sites throughout the project there were no recorded observations of TPP, even though the site is in a medium pressure zone and historically would have expected to see them. At the other sites TPP were observed, although the infestations were minor and easily controlled. One site removed liberibacter infected plants even though no stages of the TPP lifecycle were observed. Anecdotally, the TPP infestations in the presence of BCAs were quite limited in distribution. These were largely contained on 1-2 heavily colonised plants rather than spread more lightly throughout the site.

Unfortunately, as mentioned above, due to biosecurity issues, the trial sites were not able to be used as demonstration sites.

2.4.3.4 Discussion/Key Learnings

The distribution of banker plants was explored, with the key observation that they cannot be distributed within the crop as they are rapidly left behind as the tomato plants grow so quickly. The conclusion was they are best grown at the row ends and flowers containing BCAs distributed to any hotspots.

The use of an IPM approach across these sites has resulted in a large improvement in pest control and associated significant increases in both fruit quality and overall production.

The use of *B. whitei* as a spot treatment for TPP infestation was explored in an area with extremely high external TPP pressure. At this location the TPP did not spread liberibacter. In two consecutive seasons the grower did not require any chemical intervention for TPP until months later than historically recorded as he released *B. whitei* directly onto any infested location as observed.

2.4.3.5 Timeline/Budget

	Budget Revised June 2022	Actual	Comments
Commence date		Sep 21	
Conclude date		Mar 25	
Cash	0	0	No cash budget for this activity.
In kind			

2.4.3.6 Conclusion

Having laboratory based research tested in commercial settings was paramount if growers were going to take this project seriously. Having a number of trial houses involved was a good safety measure to the success of the project as commercial greenhouses can change tack and may need to withdraw. This could have led to the failure of the whole project. Having many trial houses take part also meant the project team had a better understanding if thresholds being developed were specific to one location or could be replicated in other areas.

3 Appendices

3.1 Appendix 1 – references - general

‘Potential of the mirid bug, *Engytatus nicotianae*, for the biological control of the tomato-potato psyllid in greenhouses’ By Emiliano R. Veronesi, David J. Saville, Chikako van Koten, Stephen D. Wratten; Stephen L. Goldson published June 2022 and available here: https://www.sciencedirect.com/science/article/abs/pii/S0261219422000370

‘Insect biological control of the tomato-potato psyllid *Bactericera cockerelli*, a review’ by Emiliano R. Veronesi, Christopher J. Thompson , Stephen L. Goldson published June 2023 and available here: https://www.tandfonline.com/doi/full/10.1080/01140671.2023.2229770

‘Protocol for determining infestations of whitefly’ by William Godsoe, Emiliano Veronesi and Stephen Goldson published July 2022 available online here: https://www.tomatoesnz.co.nz/ipm

Tobacco as Banker Plant for *Macrolophus Pygmaeus* to Control *Trialeurodes Vaporariorum* in Tomato Crops by Cécile Bresch, Lydia Ottenwalder, Christine Poncet , Pia Parolin. Universal Journal of Agricultural Research 2(8): 297-304, 2014 DOI: 10.13189/ujar.2014.02080

‘Whitefly and TPP scouting in tomato greenhouses’ by Emiliano Veronesi and William Godose, Lincoln University June 2022

3.2 Appendix 1.1 – references - Side effects data references

Koppert side effects database (App can be accessed here https://www.koppert.com/koppert-one/#access)

Biobest side effect data (App can be accessed here https://www.biobest.com/side-effects-app)

Koppert publication ‘Knowing and Recognising: The biology of pests, diseases and their natural solutions’ first published 2000 and revised in 2003. Available for purchase here: https://www.koppert.com/news-information/knowing-recognizing/

Side effects of insecticides against some beneficial species, Mineva et al, 2024 Journal of Agricultural sciences.

Effect of 37 conventional insecticides on functional response parameters of Macrolophus pygmaeus 38 on Tuta absoluta. Sharifian et al 2016

Lethal and sublethal effects of organic production approved insecticides and fungicides on the predator Macrolophus pygmaeus. Betski et al 2023

Sublethal and transgenerational effects of reduced risk insecticides on Macrolophus. Matioli et al, 2024 Journal of Neotropical Entomology

Risk Assessment of Insecticides used in Tomato to Control Whitefly on the Predator Macrolophus basicornis, Matioli et al 2021 Insect.

New Zealand Journal of Crop and Horticultural Science

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tnzc20

3.3 Appendix 2 – online links to all project resources

All written resources produced as a result of this project are available to download here: https://www.tomatoesnz.co.nz/ipm/

All video resources produced as a result of this project are available to watch here: https://www.youtube.com/@TomatoesNZ

The effect of chemicals on BCAs is contained in the Residue Compliance Information Booklet 2025 available for downloading here: https://www.tomatoesnz.co.nz/about/useful-docs/

3.4 Appendix 3.1 – Report on initial survey findings (conducted in 2022)

Report to TomatoesNZ Inc Board by Lex Dillon

ALT Research and Project Activity

As at 31st March 2022

Introduction

This report summarises the work that is being done on the Tomatoes NZ- ALT – Beneficial Insect Project.

In particular it reports the results of a survey of seven growers that set out to establish:

- A baseline for what level of beneficial bio control is currently being used by NZ growers
- What might the economic benefits be of increased and more effective bio control

The trial work done to date is also summarised and any issues and or opportunities going forward.

Grower Survey

Over the last few months I have been carrying out a survey of a number of growers. This included four larger growers, one medium size grower, one small grower, and one consultant who deals with many small growers. There were both North and South Island participants

There are many different types of growing structure, location, microclimates internal technological systems etc throughout NZ. To simplify the survey process, and to enable some sort of comparison, I used the following parameters.

- The survey was based around large loose tomatoes or truss
- The production was long crop i.e. 1 x crop rotation over 12 months
- There are obviously production volume differences between summer and winter plantings, and most large growers do both. I have tended to use winter plantings (maximum production potential)
- Growers surveyed marketed product to all potential channels. Ie supermarkets, wholesale markets, farmers markets, food service, export etc.

Note - Much of the information provided was commercially sensitive therefore I have aggregated and averaged the information provided, so that no individual participant can be identified.

A big thankyou to everybody that participated in the survey

Survey Method.

Before commencing the survey I prepared two survey forms. This provided the structure around which I interviewed each of the growers. In some cases I spoke to more than one individual within an organisation. Wherever possible I did interviews face to face, but one was done by telephone. The sample was not random, but was done in such a way as to include the majority of production volume and area. I would estimate that the growers interviewed would produce between 70% and 80% of the loose and large truss volume.

Crop Protection Programmes- Establishing a Baseline

Current Use of Biologicals

Five of the seven growers surveyed were currently using some form of biological pest control (IPM). One of the larger growers was solely chemical and, the consultant, (who provided me with an overview of smaller grower pest control) indicated that the majority of smaller growers were primarily chemical.

All of the larger growers had multiple production modules (sometimes within the same site) and their use of biological control depended upon where the site was located and whether past use of biological control had been effective. Potential psyllid incursions were seen as a barrier.

Growers using IPM, started crops using biological control, and gradually moved through to chemical control as pest pressure increased.

This process was often gradual and biological control is supported by mechanical (sticky traps etc) plant soaps and soft sprays, before chemicals requiring withholding were introduced. Some growers are successfully managing crops with biologicals and soft sprays without the need to use harder chemicals. Note - no grower was 100% biological.

There is no consistent threshold to switch from biological to chemical control. Each business had its own tolerance levels (for whitefly), and this depended upon the guidance and expectations of senior management. Generally, growers are given significant leeway to manage crops, however, they are held accountable for crop failures and poor production, therefore tend to be conservative with biologicals.

The largest impediment to more biological control is Psyllid incursions. Psyllid control generally involves harder sprays, which significantly impedes the use of biologicals.

To quote one grower “if you can get me something that can effectively control psyllids, I will switch to IPM tomorrow”

Crop Scouting

Good Crop Scouting is a fundamental tool that must occur for effective biological control.

All of the larger growers employed staff who had crop scouting as a specific work task. Several had staff whose only job was crop scouting. Medium and smaller growers generally work in their own crops and both surveyed dedicated some hours each week to spend time within the crops to specifically look for pests, beneficial insects and disease.

It was pleasing to see that almost all growers did scouting though with the smaller growers, this tended to be part of their general work activities rather than a dedicated process

Scouting was carried out daily on most large sites with extra scouting occurring as and when hot spots were identified.

Training glasshouse crop workers in basic pest identification provided many extra sets of eyes and is a best practise work strategy that should be adopted by all growers.

Decision Making

I questioned participants as to why they might change from using IPM to hard chemicals and whether there was a set process for this.

Those who had been involved in export to Australia, had thresholds for psyllids that required specific actions (hard sprays) at predetermined incursion levels. Other than that the changes were largely determined within each growing business.

Growers within the larger businesses were generally empowered to make these decisions however, they usually consulted with others within their organisations, and sometimes with outside consultants, agrichemical or seed suppliers.

As previously noted growers are held accountable for achieving budgeted production levels, therefore they tend to be risk averse.

One grower suggested that “the greatest business risk was not changing pest control strategies at the right time”

In the current business environment, most participants agreed that their businesses are more risk averse than in the past.

The biggest risk of continuing with IPM is where a serious pest incursion reduces production and potentially economic viability.

Crop Economics

The economic viability of a glasshouse crop is a combination of two measures.

Firstly there is the revenue generated by the sale of the product and secondly there are the costs of production. For the purposes of the survey we only considered the costs involved with pest management.

To compare one property with another the most would use square metres of production area.

Let’s consider a simple example. A one hectare glasshouse produces 580,000kgs of tomatoes in a year (58kgs per m^2). Let’s assume the average price is $2.50 per kg which provides a gross revenue of $1,450,000 or $145per m^2. To make more revenue the grower has to either increase the average price or increase his production. If he increased production to 630,000kgs (63kgs per m^2) revenue increases to $1,575,000 or $157.50 per m^2.

Conversely, should production reduce, as will happen with out of control pests, the $ per m^2 will reduce, potentially putting the grower into a loss.

It is difficult for growers to extract higher prices from growing in biologically friendly ways. What they have been able to do is increase production kgs, (through less stress on the plants) and generate higher returns. If however, the cost of using IPM is higher, then the extra income may be eroded or totally negated.

Note - Crop protection methods are not the only factor determining increasing production volume, therefore care needs to be taken in drawing any black and white economic conclusions.

What might success with increased biological control look like

- Higher quality fruit, meaning higher grades at the packhouse = more revenue
- Greater volumes of fruit i.e. more kgs per m^2 = more revenue
- Lower pest pressure = healthier crops= reduced labour = reduced costs
- Less spray applications = reduced chemical costs
- Greater efficacy of the chemicals that are currently available = reduced cost
- Better public perceptions of produce at retail

Performance indicators

Most growers use key performance indicators in their crop economics

The frequency of measurement varied, with larger growers measuring weekly, monthly and annually, and smaller growers tending to do this on an annual basis

Typical measures include.

- Kgs per m^2
- $ per m^2
- Crop Protection costs per m^2
- Percentage of off grade fruit.

With the exception of one grower, biological control costs were not specifically separated from, chemical control costs.

Production Potential – (with current technologies and glasshouse structures)

As part of the survey process, I endeavoured to establish how many kgs per m^2 a perfect crop grown in New Zealand circumstances should produce. We are often quoted overseas figures of 80 to 100 kgs per m^2, so I asked growers whether this is possible in NZ and the answer was a resounding no. At least not with current growing structures and technology

Results as follows

- The average maximum production was considered to be 72kgs per m^2
- The highest maximum production was considered to be 80kgs per m^2
- The lowest maximum production was considered to be 65kgs per m^2

The range between the lowest and the highest was 15 kgs per m^2

I then asked, What is the current actual production?

Results as follows

- The average actual production was 65kgs per m^2
- The highest actual production was 68kgs per m^2
- The lowest actual production was 58kgs per m^2

The range between the lowest and the highest was 10 kgs per m^2

Note - These are shortest day planting figures. Crops planted to run through the winter will have lower production levels.

Based upon the averages (actual/potential) (65kgs/72kgs), our industry considers we have the potential to increase production by 7kgs per m^2.

If we look at the range of (lowest actual/ highest potential), then this suggests the possibility of 22kgs per m^2.

As previously indicated, effective pest control is but one of the factors that limits our production potential, however, it would not be unreasonable to suggest that we could gain between 0 and 3kgs per m^2, through improved pest and disease control. We do know that reducing the number of sprays leads to healthier plants, which equals more production.

Note - I was surprised at how low maximum production expectations were. I believe these expectations have decreased in recent years, as pest control, energy cost/availability, labour cost/availability and the general ageing of our industries technology has impacted upon actual production.

Average Price per kg

This was a particularly sensitive area in my discussions with growers and answers were generally given to me in ranges. For example, say $2.60 to $2.80 per kg. Different growers also measure their revenue dollars at different points, so adjustments have been made to allow some comparison.

Results as follows

- The Average Gross Sales price was $2.82
- The Highest Average Gross Sales price was $3.25
- The Lowest Average Gross Sales price was $2.70

Note - Some of the smaller growers were estimated to have figures lower than the Lower Average Gross Sales price and were not included in this calculation. Many smaller growers don’t do full 12 month cycles and the smaller sales volume could distort the numbers.

Potential Economic Benefits

If we assume that the effective use of biological control methods was to increase production by 1kg per square metre, then for every hectare of production area, we would see the value of the industry increase by $28,200 (assuming the increased volume did not distort price). We have average increased production potential of at least 7kgs per m^2.

Depending upon the costs of beneficials’ (and this has yet to be determined) there is potential to reduce the overall cost of pest control. This is through a reduction in both chemical and application (labour) costs.

There is also the benefit of the public’s perception of our industry though this is difficult to quantify in economic terms.

Project Work to Date

The initial plan for 2022 was to use the T&G Ohaupo site to test the efficacy of *Engytatus* against white fly. There was to be a 1 hectare test site with a 2 hectare control. The plan was to build up sufficient population of beneficials so that if a Psyllid incursion happened, then we could test whether the *Engytatus* could handle this in a live glasshouse situation. *Engytatus* was to be supported by the inclusion of *Encasia*. Unfortunately, the base population of *Engytatus* was not sufficient to provide the weekly numbers. *Encasia* was adequately controlling the whitefly, however an early Psyllid incursion meant chemical intervention was required.

Early in February it was identified that the supply issues of *Engytatus* could not be resolved in the short term. There needed to be a break in weekly deliveries to allow the base population to build up. Discussions were held with Emiliano and Lincoln University to see if, further trial work could be actioned at Lincoln University.

An issue that required greater understanding was - what are the appropriate numbers of *Engytatus* needed to be introduced into crops, that can both build populations and control possible pest incursions.? i.e. application rates. Lab trials have been designed to test this and are expected to be up and running in the next month or so.

Additional work has also been done with Lincoln University, to statistically validate the scouting numbers, that are required to get the level of accuracy needed to get good decision making i.e. unless you scout every plant every week, you cannot be 100% accurate.

It would be nice to have this level of surety; however, the cost is unrealistic. Work has been done to create a model for growers to use, that allows them to calculate, if I want to be 90% sure (or any other accuracy level), how many plants/heads should I sample?

There are regular (weekly) zoom meetings of the project team to work through the issues as they arise. A big thankyou to the growing team at T&G for facilitating this.

Points/Issues that have been highlighted to date

- Beneficial methods of pest control are primarily preventive in nature rather than reactive i.e. if you have established levels of pests it is almost impossible to introduce beneficials that will knock the established population back. Chemicals are the best tool in reactive situations.
- Adequate supply levels of *Engytatus* (or any other beneficial) are essential for any growers to consider increasing their levels of IPM programmes. The cost of using *Engytatus* has yet to be determined and as well as being effective, it will need to be economic. Ensuring we have the production capacity is an issue.
- The grower survey indicated that the majority of New Zealand's loose tomato production is grown by growers using IPM systems. Most crops are started without the use of chemicals and there is good use of crop scouting systems to identify pest incursions as and when they occur. In many cases much of the crop can be produced without the need for hard conventional control intervention.
- There are however a number of production locations where background pest pressure is such, that the use of biological control methods is either not practical or economic.
- The Psyllid remains the single greatest barrier to increased use of biological control methods. The work that is currently being done on *Engytatus* as a tool to control Psyllids (and whitefly) is essential to establish a platform around which other biological tools can be developed.

Summary

We would like to have more progress to report, however the nature of these research projects is that they take time, and unexpected issues occur along the way.

We have identified a number of issues that require resolve and have put plans to address these.

New Zealand's growers have a good understanding of the need to develop effective biological control systems and a willingness to implement them if both effective and economic.

We have a good base to work off.

3.5 Appendix 3.2 – Report on post project survey findings (conducted in 2025)

End of Project Survey

Tomatoes NZ- A Lighter Touch Project

September and October 2025

Introduction

Tomatoes New Zealand and A Lighter Touch have been undertaking research to help growers to introduce and use biologically friendly pest control systems into Tomato glasshouses.

The project has been operating for approximately four years and initially focussed upon *Engytatus nicotianae* which had shown positive results in laboratory trials. After a reset, the trial developed into a broader research project with the inclusion of additional beneficial insects and other methods of environmentally friendly pest control methods.

Research Participants

Six different growers and one beneficial insect supplier were included in the survey. The growers included three out of the four largest tomato growers. There were also two smaller growers and one consultant (an ex grower) who deals with a number of smaller growers. There was a good geographical representation with both North and South Island growers included. It would have been preferable to include all large growers however there was difficulty in organising a suitable time for the excluded grower

All of the larger growers had multiple growing sites and their answers reflected the overall business.

Questions asked

I have attached a copy of the questions asked to this report. Not every question was relevant to every grower therefore, not every result reflects all growers.

The questions asked of the beneficial insect supplier were also slightly different and will be commented upon in the report.

Survey Results

Current use of Biological Pest Controls

All of the growers surveyed were using some sort of biological pest control. This was generally part of IPM systems with agrichemical use still a part of pest control. One of the larger and one of the smaller growers had made significant change

The exception to increased use was the consultant who advised that most smaller growers he dealt with were still predominantly using chemical control.

The beneficial insect supplier commented that he would estimate that there would be a 25% to 30% increase in volume of BCAs being used compared to the beginning of the project.

Five of the six growers had trialled *Engytatus* with differing levels of success. Growers who were able to establish breeding populations tended to be more supportive of *Engytatus* use.

One grower commented that “they didn’t feel that *Engytatus* had delivered as they had hoped for Psyllid control but that it had helped with whitefly”

Had beneficial use has:

- increased for three growers (one large and one small grower said ‘significantly’)
- remained about the same for two growers
- not decreased for any grower

Have the research and resources developed been helpful?

All growers commented that the trials had helped them with better understanding of how they should be using beneficial insects. Sharing the learnings of what was working and what wasn’t was particularly valuable.

Larger growers felt that the resources were of greater benefit for growers that were new to IPM, but that the knowledge was beneficial to all.

Most growers felt that the resources developed to date were sufficient to give growers help to establish IPM systems. There was a need to update resources as new knowledge was gained.

One of the large growers was keen to see further research into whether Liberibacter can be mechanically spread.

A second grower wanted to see more research into native BCAs.

Current Pest Issues

Are Psyllids more of a problem, less of a problem or about the same as the start of the trial?

Comments from growers as follows:

- “changes year by year but, we can live with them better”
- “always there, but they are more manageable”
- “less of a problem, we are learning to tolerate some Psyllids”

The use of *Engytatus* as a preventative appears to have reduced the number of Psyllids in glasshouses, but if a grower gets a Liberibacter infection, it can still be a significant problem for them.

Whitefly continues to be the pest that is causing most growers concern. This was unanimous across all growers.

Yes, there are developing pest issues. Where growers are reducing spray use and where they are managing Whitefly and Psyllids, they are seeing increases in other pests. Caterpillars and Thrips were two pests raised. There is also general concern about *Tuta absoluta* as a potential issue.

Chemical resistance continues to be an issue.

Crop Scouting

The larger growers all have dedicated crop scouts. Smaller growers tend to undertake scouting as part of their general work practises.

Risk

This question was to get an understanding of whether growers tolerate some levels of pests within their glasshouses. An attitude that is essential if you are to use biological pest control.

One grower stated:

"I am not paranoid, but I am wary. You learn to tolerate a reasonable amount as long as you are confident that you can get it back under control"

Different growers have different tolerance levels however, the response above seems to indicate that the survey participants don't necessarily reach for the chemicals as a first option.

Estimated Average Production

One of the key benefits of successful IPM systems, is increased production volume. Having a "clean" crop is however, not the only input that effects production volume.

I asked growers what they thought a loose fruit variety, planted on the shortest day, could achieve in kgs per m^2.

Note: Five growers answered this question and, answered with a range rather than a specific number e.g. 55kgs to 60kgs

The average was 60.6kgs

The high was 70kgs

The low was 45kgs

I then asked where they thought the actual production is:

The average was 54.5kgs

The high was 62.5kgs

The low was 40kgs

Note 1 - Growers commented that the impact of viral disease such as Pepino Mosaic was having an impact on production volume

Note 2 - Growers also expressed concern about increasing energy prices and the potential effect that this may have on production volume.

Resources to Help Increase the Use of Bio-controls

General discussions were held with survey participants as to what else needs to be done to encourage growers to use BCAs. To quote one;

“it would take hitting some of them over the head with a hammer to get them to change”

His point being that for some growers, the issue is not about resources or knowledge, it is about will.

It will not be until they have a crop failure, that these growers will put in the time and effort to change to BCAs

There are however some real issues that growers expressed concern about:

1. Logistics

The further the grower is away from the BCA supplier. The greater the risk for logistics to negatively impact upon regular supply of product.

A grower in the South Island commented:

“getting regular deliveries of good, live BCAs has been a problem”

2. Production of BCAs

Some growers expressed concern that they were not able to get supplies of BCAs when they needed them. More availability would increase the overall usage of BCAs

A separate discussion with NZ’s largest BCA supplier captured the following:

1. Logistics

This is difficult for the supplier to resolve. While there are occasional issues in the North Island, the main problem appears to be the South Island. There are limited carrier options to resolve this.

2. BCA Supply

Plans are in place to significantly increase production capability which should resolve this issue. It is also important for growers to set long term supply agreements.

Note - it would be great if there were multiple BCA suppliers but the commercial reality is that the size of the NZ market precludes this.

I also asked what changes had occurred with tomato growers and BCA usage.

- It has increased grower focus on attention to detail
- It has helped to foster engagement with industry organisations i.e. TomatoesNZ and the work they do with growers.
- A real positive was the increased discussion and knowledge sharing within the larger businesses. One large grower has a dedicated weekly meeting to discuss pest issues, BCA usage, and knowledge sharing
- There has been interest from some small growers but few have started using BCAs
- The success of the TomatoesNZ /ALT project has stimulated interest elsewhere in horticulture and there is increased demand from other product groups.

Note - the survey did collect data on expected pricing, but I have not included that data in this report. One of the trialists was able to prove economic benefit from their switch to BCAs, but generally growers have such a broad variety of different factors, that it is difficult to draw specific correlations with cost benefit from a single input. e.g. BCA use.

Summary

- Growers responses were positive towards the work carried out on the BCA project
- Those growers motivated to change are doing so and there have been some very positive results. Note - a smaller grower has reduced his use of chemicals by 70% to 80%
- The knowledge base of BCA usage has grown considerably
- The project has created some excellent resources and provided numerous communications and learnings opportunities for growers
- Having said that, some growers still see BCA usage as “too hard” and will not change until crop failure forces them
- There is a need to update the resources that have been produces on a regular basis and to also share growers’ experiences as BCA usage develops.
- There may be a need for an annual workshop that focuses on BCAs and IPM

Lex Dillon

Project Technical Lead

31st October 2025

3.6 Appendix 4 – Effect of chemicals on BCAs

Insecticide Compatibility

Active Ingredient	Bumblebees	Parasitoids	Mirids	Lacewings	Mites	Pirate Bugs	Registered on indoor tomato?
ABAMECTIN	R, 2 D	4 / 3W	4 / 1W	4 / >1w	4 / 2W	4 / 1-6w	Y
ACRINATHRIN	R, 2 D	4	4	3 / 0W	4	4 / >4W	Y
ALPHA-CYPERMETHRIN	IC	4 / 8-12W	4 / 8-12 W	4	4 / 8-12W	4	N
AZADIRACHTIN	C	2	2	1	1	2	Y
BACILLUS THURINGIENSIS		1	1	1	1	1	Y
BEAUVERIA BASSIANA	NA						Y
BIFENTHRIN	IC / 7D	4 / 8-12 W	4 / 8-12 W	4 / 8-12W	4 / 8-12W	4 / 8-12W	N
BUPROFEZIN	C	2 / 0W	1	1	1 / 0W	2 / 0W	Y
CARBARYL	R, 2 D	4 / 3W	4 / 8W	4 / 4W	4 / 6-8W	4 / 8W	Y
CYANTRANILIPROLE	NA			1 / 0W	2	1 / 0W	N
CYPERMETHRIN	IC / 14 D	4 / 8-12W	4 / 8-12W	4 / 8-12W	4 / 8-12W	4 / 8-12W	Y
DELTAMETHRIN	R, 3 D	4 / 8-12W	4 / 8-12W	4 / 8-12W	4 / 8-12W	4 / 8-12W	N
DICHLORVOS	R, 2 D	4 / 1W	4 / 1W	4 / 1W	4 / 1W	4 / 1W	Y
ESFENVALERATE	IC / 15 D	4 / 8-12W	4 / 8-12W	4 / 8-12W	4 / 8-12W	4 / 8-12W	N
FATTY ACIDS (K SALTS)	C	4 / 0W	4	4	4		N
FLONICAMID	NA	1 /0W	1 / 0W	1 / 0W	1 / 0W	1 / 0W	N
IMIDACLOPRID	IC / 30 D	4 / >12W	4 / 4-6W	4	4 / 2W	4 / 4-6W	N
LAMBDA-CYHALOTHRIN	IC / 15 D	4 / 8-12W	4 / 8-12W	4 / 8-12W	4 / 8-12W	4 / 8-12W	N
METHOMYL	R / 3D	4 / 8-12W	4 / 8-12W	4 / 8-12W	4 / 8-12W	4 / 8-12W	Y
OILS	R /1D	1 / 0W	4 / 1W	1 / 0W	3	3 / 0W	N
PERMETHRIN	IC / 9D	4 / 8-12W	4 / 8-12W	4 / 8-12W	4 / 8-12W	4 / 8-12W	Y
PIRIMICARB	R / 1D	2 / <1W	2 / 2-3W	2	2	2	Y
PIRIMIPHOS-METHYL	IC	4 / 6-8W	4	4 / 6-8W	4 / 6-8W	4	N
PYMETROZINE	NA	1	3 / 1W	1 / 0W	1 / 0W	2 / 1W	Y
PYRETHRINS	R / 1D	4 / 0W		2 / 1W		4 / 1W	Y
PYRIPROXYFEN	NA	3	1 / 0W	1 / 0W	1 / 0W	1 / 0W	Y
SPINETORAM		4 /1W	3	4	3	4 / <1W	N
SPINOSAD	C / 1D	3 / 1W	3 / 3-6W	4	3	2	N
SPIROMESIFEN	NA	1 /0W	1	2	2	1	Y
SPIROTETRAMAT	R / 1 D	2	1	1 / 0W	2	2	N
SULFOXAFLOR		4 / 2W	4 / 2W	1	1	3 / 1W	Y - fruiting vegetable
TEBUFENOZIDE	NA	1	1	1 / 0W	1	2	N
THIACLOPRID	NA	3	4	3	2	4 / 2W	N
VERTICILLIUM LECANII							Y

Legend - Impact / Persistence

Bumblebees
NA - No Action
C - Cover
R - Remove
IC - Incompatible

Persistence
D - Days
W - Weeks
- Indeterminable

Beneficial Insects
1 - Harmless - 0 to 25% mortality
2 - Moderately harmful - 26 to 50% mortality
3 - Harmful - 51 to 75% mortality
4 - Very harmful - 76 to 100% mortality

DISCLAIMER: Every effort has been taken to provide accurate information in this resource but TNZ and ALT disclaim all liability in relation to the information it contains. Seek further advice from suitably qualified people before embarking on an IPM programme using beneficial insects. JUNE 2024

Fungicide Compatibility

Active Ingredient	Bumblebees	Parasitoid	Mirid	Lacewings	Mites	Pirate Bugs	Trichoderma	Registered on Indoor tomato?
AMETOCTRADIFN								N
AZOXYSTROBIN	C	2 / 0W	1 / 0W	2 / 0W		1 / 0W	1 / 0W	N
BACILLUS AMYLOLIQUEFACIENS BS1B								Y
BACILLUS SUBTILIS	C / 3D							N
BENZALKONIUM CHLORIDE								Y
BOSCALID	NA				1 / 0W			N
BUPIRIMATE	C	1 / 0W	2 / 0W	1 / 0W	1 / 0W	2 / 0W	1 / 0W	N
CARBENDAZIM	R / 1 D	1 / 0W	1 / 0W	1 / 0W	4	1 / 0W	1 / 0W	Y
CHLORETHEPHON								Y
CHLORINE DIOXIDE								Y
CHLOROTHALONIL	C	1 / 0W	1 0W	1 / 0W	2	1 / 0W		Y
COPPER HYDROXIDE	R / 2 D							Y
COPPER OXIDE								Y
COPPER OXYCHLORIDE	C	3 / <1W	1 / 0W	2	1 / 0W	1 / 0W	4	Y
COPPER SULPHATE	C						2	N
CYPRODINIL	C				1 / 0W	2		N
DIFENOCONAZOLE	NA	1 / 0W	1 / 0W	1 / 0W	2	1 / 0W	1 / 0w	N
DIMETHOMORPH	R / 1 D		2			3	1 / 0W	N
FLUAZINAM								N
FLUDIOXONIL		1 / 0W				1 / 0W	1 / 0W	N
FLUOPYRAM		1 / 0W	1 / 0W		1 / 0W	2	1 / 0W	Y
IPRODIONE	C	1 / 0W	1 / 0W	1 / 0W	1 / 0W	1 / 0W	1 / 0W	Y
KRESOXIM-METHYL	NA	1 / 0W			1 / 0W	1 / 0W	2	N
MANCOZEB	NA	2 / 0W	1 / 0W	2	2	2	1 / 0W	Y
METALAXYL	NA	1 / 0W			3		1 / 0W	N
METALAXYL-M		1 / 0W			3			Y
MINERAL OIL	R / 1 D	1 / 0W	4 / 1 W	1 / 0W	3	3 / 0W		N
MYCLOBUTANIL	NA	1 / 0W	1 / 0 W	1 / 0W	1 / 0W	1 / 0W	1 / 0W	N
PHOSPHOROUS ACID/ INORGANIC PHOSPHOROUS							1 / 0W	N
POTASSIUM BICARBONATE	NA							Y
PROCHLORAZ		1 / 0W		1 / 0W	2			N
PROCYMIDONE	NA	1 / 0W	1 / 0W	1 / 0W	1 / 0W	3		N
PROPAMOCARB					1 / 0W	2		N
PYRACLOSTROBIN	C							N
PYRIMETHANIL	NA	1 / 0W	1 / 0W	1 / 0W	1 / 0W	1 / 0W	3 / 2W	N
SULPHUR	NA	4	4	1 / 0W	2	2		Y
THIOPHANATE-METHYL	NA	4	1 / 0W	1 / 0W	3 / 2-3W	1 / 0W	1 / 0W	Y
THIRAM	NA	3 / 1W	1 / 0W	1 / 0W	1 / 0W	2	4	Y
TRIADIMENOL	NA	1 / 0W		1 / 0W	1 / 0W	1 / 0W	1 / 0W	N
TRICHODERMA ATROVIRIDE	NA	1 / 0W	1 / 0W	1 / 0W	1 / 0W	1 / 0W	1 / 0W	Y
TRIFLOXYSTROBIN	NA	1 / 0W	1 / 0W	1 / 0W	1 / 0W	2		N
TRIFORINE	NA	1 / 0W	1 / 0W	2 / 0W	2 / 1W	1 / 0W		Y

Legend - Impact / Persistence

Bumblebees

NA = No Action
C = Cover
R = Remove
IC = Incompatible

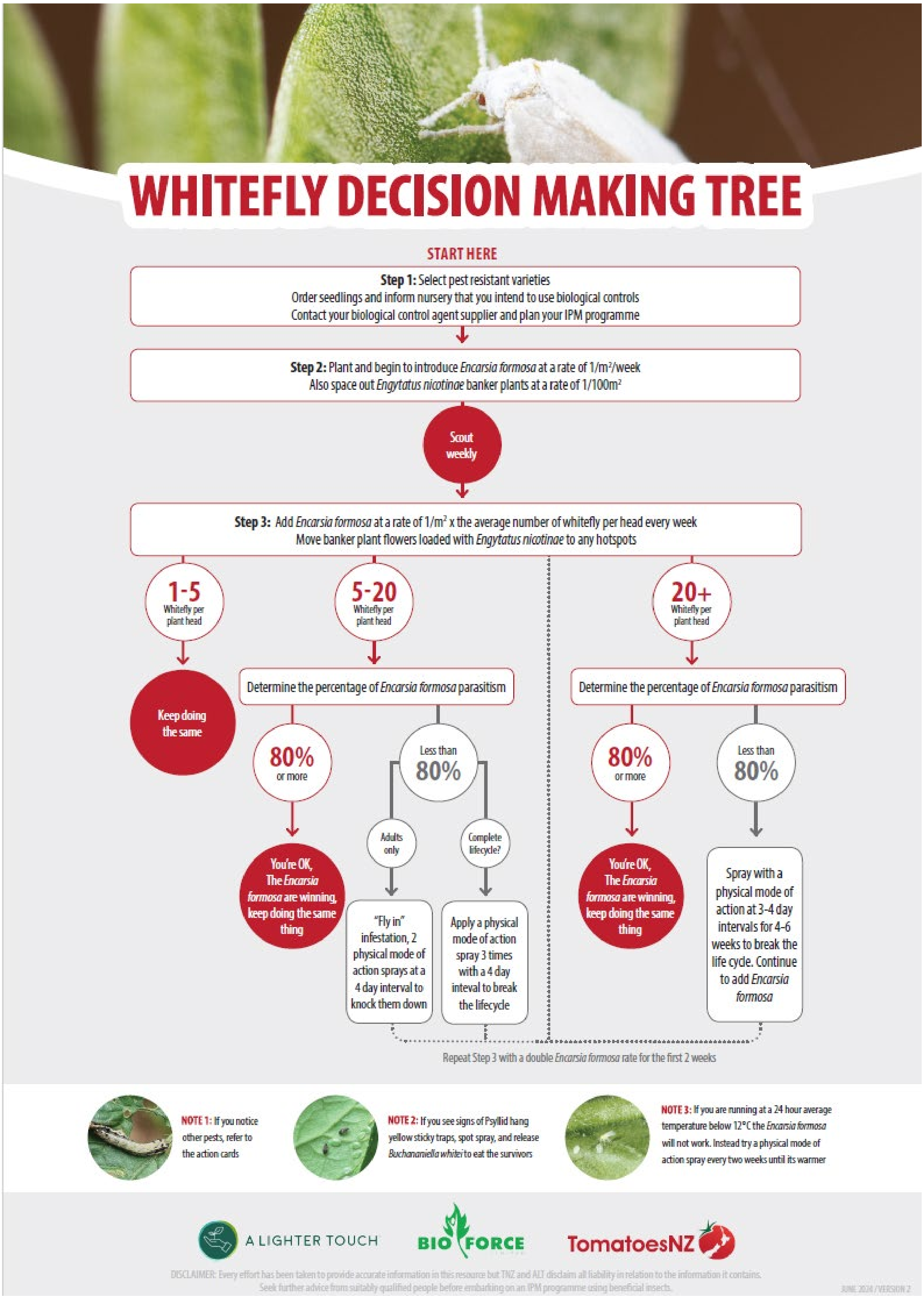
Persistence

D = Days
W = Weeks
= Indeterminable

Beneficial Insects

1 = Harmless - 0 to 25% mortality
2 = Moderately harmful - 26 to 50% mortality
3 = Harmful - 51 to 75% mortality
4 = Very harmful - 76 to 100% mortality

3.7 Appendix 5 – Written Resources for Growers



WHITEFLY DECISION MAKING TREE

EGG

The eggs will turn black before hatching

LARVAE

PUPAE

Pupae will be white if not parasitised

ADULT

Female adults start laying eggs 2 days after emerging

Average time from 1 Egg to 4 Adult

Temperature	Days (approx)
15°C	46.4 days
20°C	25 days
25°C	19 days

Approx Life cycle length at 20°C*

Life Stage	Days (approx)
Egg to Larva	9 days
Larva to Pupa	11 days
Pupa to Adult	5 days

*as per '*A temperature-dependent phenology model for the greenhouse whitefly Trialeurodes vaporariorum (Hemiptera: Aleyrodidae)*'

A LIGHTER TOUCH BIO FORCE TomatoesNZ

JUNE 2024 / VERSION 2

Psyllid

Main problem Species:
Tomato Potato Psyllid (TPP) *(Bactericera cockerelli)*

Lifecycle:
Egg, 5 nymphal instars, adult

Egg to egg:
Shortest time, 19 days, at 27°C. Increases to 45 days at 10°C.

POTENTIAL CONTROL MEASURES FOR 'HOT' POPULATIONS
- When first observed, hang a sticky card above every infested plant and every plant within a 5 plant radius
- Spray the area with a physical mode of action chemical
- When dry, carefully remove any heavily infested leaves and plants, sealing them in a plastic bag immediately, before removing them
- Release *B. whitei* and *E. nicotinae* in the area to remove any survivors

Scouting tips:
Eggs are easily visible around leaf margins from below. Adults may be observed on sticky traps or sitting on leaves. Once eggs hatch the juveniles cover the plant surface in "psyllid sugars" and liquid excreted sugars leading to a sticky, dirty plant. Over time plants can appear stunted (psyllid yellows) or die due to liberibacter, a bacteria-like organism spread by psyllid as they feed.

Yellow sticky traps are the easiest way to detect the early signs of a psyllid incursion. As with whitefly monitoring, they should be positioned near any greenhouse openings, historic trouble spots and randomly throughout the crop. Adults may also be observed sitting on leaves.

What do I do?

Just a few:
- Sticky traps can suppress small localised populations
- Physical mode of action sprays can rapidly reduce a localised population
- *Buchananiella whitei* effectively cleans up juvenile populations
- *Engytatus nicotinae* releases can totally suppress psyllid if introduced early enough
- *Tamarixia triozae*, a tiny parasitic wasp (similar to *Encarsia formosa*) feeds on small TPP larvae and parasitises large larvae. A useful psyllid predator but not as effective as *Engytatus nicotinae*.

Doing damage:
If a liberibacter carrying population is present, use physical spray or soft agchem to quickly control the population, then release *Engytatus nicotinae* to prevent re-infestation.

Ongoing issue:
- Try to remove the source
- Introduce an *Engytatus nicotinae* population
- Use sticky traps to monitor adult populations
- Use soft chemical options as required

Psyllid

What you'll observe:

As psyllid inhabit the underside of leaves, they can be difficult to see. The first obvious sign of psyllid might be psyllid sugars

Psyllid sugars

Psyllid egg

Green psyllid nymph with black *Buchananiella whitei*

DISCLAIMER: Every effort has been taken to provide accurate information in this resource but TNZ and ALT disclaim all liability in relation to the information it contains. Seek further advice from suitably qualified people before embarking on an IPM programme using beneficial insects. MAY 2025

Aphids

Main problem Species:

Peach aphid *(Myzus persicae)* and Potato aphid *(Myzus euphorbiae)* however, there are many species and sub species.

Lifecycle:

The lifecycle is complicated, for our purposes aphids give live birth to smaller juveniles. Once they reach a threshold population density winged adults develop and spread throughout the greenhouse.

Egg to egg:

Juveniles take about a week to mature, however their ability to give birth to multiple young simultaneously leads to the population doubling every 3 days @20°C.

POTENTIAL CONTROL MEASURES:

- The parasitic wasp *Aphidius colemani*
- The parasitoid *Aphidius colemani*
- Multiple species of ladybird (for example *Scymnus Loewii*)
- Multiple species of lacewing *Mallada basalis*
- Physical mode of action spot sprays
- Agchem sprays (last resort as resistance develops rapidly)

Scouting tips:

Usually in the plant heads, large colonies develop rapidly, plant growth stunted, plants "sticky". Interestingly aphids are "farmed" by ants which can be observed moving them around.

What do I do?

Just a few:

Squash them, order predators to eradicate the survivors. It is recommended to make small, regular releases of *Aphidius colemani* early in the season as a preventative measure.

Doing damage:

Physical mode of action spot spray all areas, then release predators.

Ongoing Issue:

Carefully select Agchem that is IPM compatible, apply, then release predators and build a population of them. Release predators regularly and early to prevent re-infestation.

Aphids

What you'll observe:

Different stages of aphid

Fall Armyworm © Klaus Birkhofer, iNaturalist

Caterpillar

Main problem Species:

Green Looper (*Chrysodeixis eriosoma*), Tropical Armyworm (*Spodoptera litura*), Stem borer (*Symmetrischema tangolias*), Fall Armyworm (*Spodoptera frugiperda*). There are more than 150,000 categorised species which should generally be treated the same way.

Lifecycle:

Moth/Butterfly, egg, caterpillar, pupa

Egg to egg:

Eggs take about a week to hatch, some species lay thousands of eggs so you need to act quickly. The caterpillars rapidly grow and after about 2-3 weeks they pupate for 1-2 weeks before emerging and laying more eggs. This is all affected by species, temperature and host plant so these are general guidelines.

Scouting tips:

You will see the damage first. Typically Armyworm damage is highly localised, other species damage can be widely dispersed.

POTENTIAL CONTROL MEASURES:

Moth/Butterfly:

Light traps (all species)

Pheromone traps, species specific:

1. As a scouting tool, use 1 trap/ha of the species you commonly encounter in your area (consult your IPM supplier for guidance)
2. Once you identify the problem species, increase the density of peromone traps for those species to 4+ traps/ha.

Caterpillar

Best controlled using sprays based on *Bacillus thuringiensis* (Bt), a live bacteria that destroys the gut and stops feeding when ingested. Efficacy decreases with increase in caterpillar size.

Currently no approved treatments for eggs or pupae.

What do I do?

Just a few: Squash them.

Doing damage: A block of 4 sprays with Bt at 7 day intervals usually solves it.

Ongoing Issue: Light traps, identify adult species, implement pheromone trapping programme. Regular Bt applications rotating around the products (different strains of Bt). Try to remove any source of infestation and be aware of any lights which could attract moths in the greenhouse. Investigate agchem approach that is IPM friendly only as a last resort. Consult your supplier for application advice.

Whitney Cranshaw, Colorado State University, Bugwood.org

Russet Mite

Main problem Species:

Russet Mite *(Aculops lycopersici)*

Lifecycle:

Egg, larva, nymph1,nymph2, adult

Egg to egg:

8.7 days @20°C, 5.5 days @25°C

POTENTIAL CONTROL MEASURES:

- Keep the environment clean by having good hygiene measures and removing all weeds
- Remove any symptomatic plants at nursery stage
- Physical mode of action spray
- Agchem spray

Scouting tips:

You will require a magnification of at least 50x to view these clearly, normally the damage they cause alerts you to their presence. Look for bronzing on leaves or stems.

What do I do?

Just a few:

Unfortunately russet mite are unlikely to be limited to 'just a few'. Once you see damage act quickly, identify and spot spray with a physical mode of action spray. Be aware that often this is not successful as these mites are easily spread on workers hands/clothes so you should probably move straight to the 'doing damage' stage.

Doing damage:

If damage is apparent at multiple locations move to an appropriate agchem solution. Check resources regarding aide effects and ensure IPM compatibility, in general Physical mode of action sprays are the most compatible with an IPM approach.

Ongoing Issue:

You must Identify and remove the source of infestation. No weeds, clean margins around the glasshouse, no moving staff between infested and non-infested rows spreading mites on clothing. Hot wash clothing daily. Regular IPM compatible spraying.

Russet Mite

What you'll observe:

As russet mite are so small, you're more likely to see the damage they cause

 JUNE 2024

Sciarid Flies

Leia varia © Gary McDonald, iNaturalist

Main problem Species:

Sciarid Flies *(Bradysia spp.)*

Lifecycle:

Fly, egg, larva, pupa.

Egg to egg:

About 20 days at 25°C, 13-18 days as a larva.

POTENTIAL CONTROL MEASURES:

- *Stratiolaelaps scimitus* predate on eggs, larvae and pupa. As the lifecycle has a long larval stage these predators are very effective.
- Yellow traps for adults
- *Bacillus thuringiensis* drenches kill larvae when consumed.
- Agchem solution.

Scouting tips:

Most of the damage occurs unseen as the larvae feed on the root zone. We are most likely to observe adults. Adults are weak flyers so normally observed close to the ground. Normally the first thing to show up on yellow sticky traps at ground level. Often confused with other small fly species but all are treated the same.

What do I do?

Just a few:
Sticky traps can suppress small localised populations, introduce *Stratiolaelaps scimitus* for ongoing control.

Doing damage:
Weekly *Bacillus thuringiensis* drench applications will quickly knock down a population. Introduce *Stratiolaelaps scimitus* to maintain control.

Ongoing Issue:
Remove the source, introduce appropriate agchem, then introduce *Stratiolaelaps scimitus* to prevent re-infestation.

Sciarid Flies

What you'll observe:

Sciarid flies on a yellow sticky trap.

Whitefly give an indication of scale.

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David Cappaert, Bugwood.org

Thrips

Main problem Species:

Onion thrips: *Thrips tabaci*. Western flower thrip: *Frankliniella occidentalis*

Lifecycle:

Adult, Egg, nymph1, nymph2, pre-pupae, pupae.
The egg is deposited inside the leaf tissue, pre-pupal and pupal stages occur on the ground, adults live for about 7 weeks.

Egg to egg:

9 days at 30°C, 40 days at 15°C,
No development below 10°C or above 35°C.

Scouting tips:

Thrips are attracted to sticky traps so trap observation is a key tool.
Thrips hatch marks on leaves are easily visible, and often gently blowing into a flower disturbs adults that can then be seen moving around.

Tomato Spotted Wilt Virus (TSWV):

Thrips are a known viral vector of tomato spotted wilt virus. Once infected, plants do not recover. Symptoms include apical bud dieback, necrotic leaf spots, ring spotting on tomatoes, and eventually plant death.

Selection of TSWV resistant varieties in troublesome areas is the best control measure. Best virus management practice includes weed control (TSWV carried in all solanaceous plants), careful removal of any suspect plants and effective thrips management.

What do I do?

Just a few:

If a few adults are observed on traps be vigilant. Infestations usually begin by the doorway, main path, and window rows. Infestations begin in a small area and then colonise the greenhouse. If you have not introduced *Stratiolaelaps scimitus* as part of your IPM strategy this is your last chance, they will predate on any thrips pupae in the media or on the ground.

Doing damage:

If the small beginning population was not scouted/treated and the infestation is large, you are limited to spraying options. Sublethal chemical treatments induce egg laying, and chemical resistance is common. Egg hatch time is 5-7 days so weekly treatments with a well applied physical mode of action sprays can achieve control. This is difficult due to the adults habit of hiding in the flowers and pupae occurring on the ground. The 1st and 2nd stage nymphs are the most vulnerable and can be found in the top 1/3 of the plant.
The other spray option is the application of nematodes. Once sprayed on they actively seek out thrips and kill them.

Ongoing Issue:

Once a greenhouse has been infested, the thrips will hide everywhere within the structure waiting for the new crop. This can be catastrophic if combined with TSWV (select a variety with TSWV resistance). Once the crop is completed all plant matter must be removed, and the entire structure washed. If all vents are closed and the sun is allowed to heat the glasshouse this is beneficial because it can kill the thrips by heat, or force the eggs to hatch in the absence of food. General good hygiene suggests spraying a 5m wide strip of barren ground between the glasshouse and any other green matter.

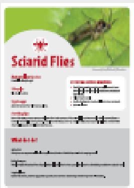
How to Scout

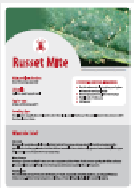
Pest recognition

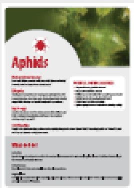
Know your enemy. The crop scout must be familiar with the appearance of common pests (and diseases) and the signs/damage they leave. **tomatoesnz.co.nz** provides regularly updated resources on common pests.

Frequency

Scouting frequency must be matched to the lifecycle duration of common pests. These can be found on the Action Cards.







Alternate rows once a week gives a 2 week rotation, this is a favourable duration for spotting most common pests as small (first generation) infestations.

Move quickly, stop at any sign of pests or every 10m (post?) for a more thorough inspection. Mark and record the location of any pest that requires further attention.

If every plant is carefully inspected scouting will take too long.

Instead, the scout should move quickly looking for signs of any pest which varies from leaf damage to the actual pest on the leaves. i.e. psyllid sugars, caterpillar damage. Once the scout is experienced any deviation in appearance from healthy will be obvious.

Scouts should be partly responsible for the pest control programme. This includes spot spraying, distribution of BCAs, and assessing their progress. Observing IPM success increases enthusiasm for the whole programme.

Equipment required

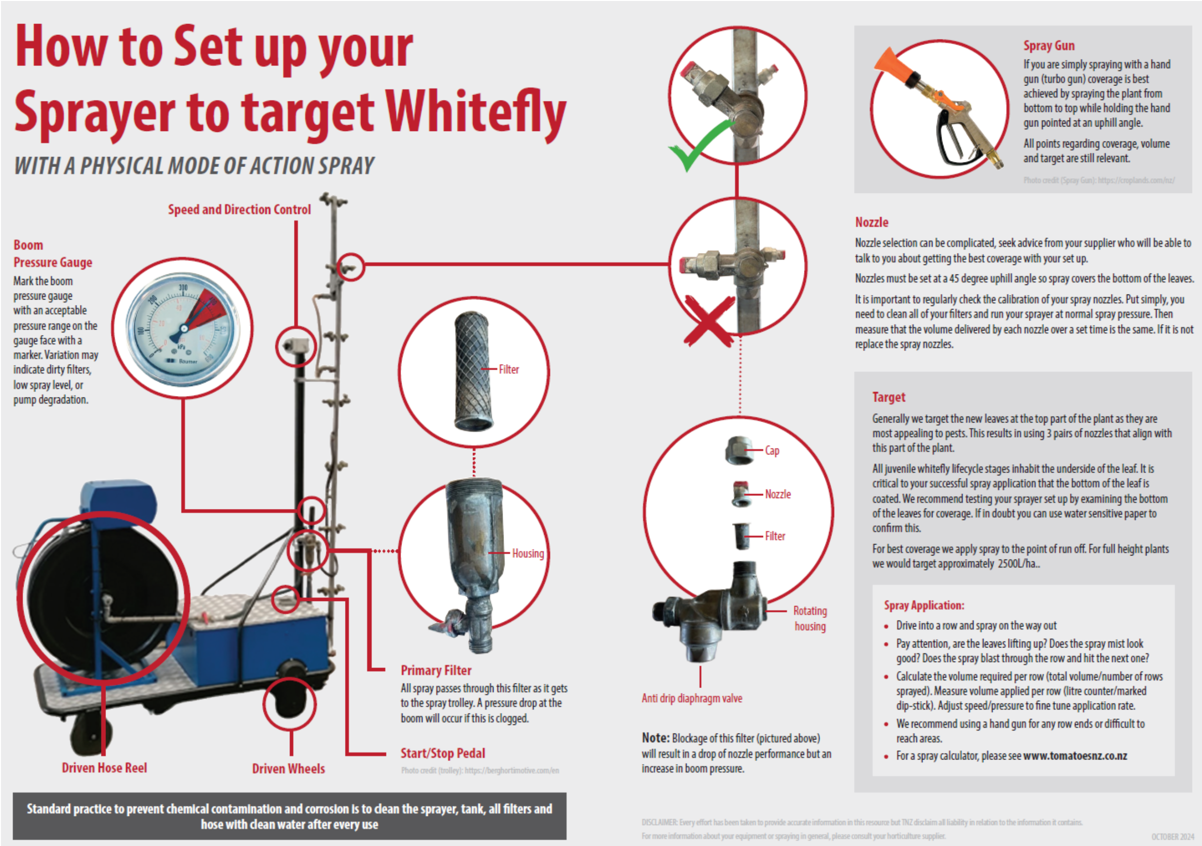
Use a 30X hand lens to make identification easier. A lower magnification will make it difficult to determine if pests are still alive.

Use sticky traps and pheromone traps to help you scout. The first signs of flying pests will appear on the sticky cards. These must be renewed regularly. Pheromone traps are most useful not only to indicate pest presence, but to determine species.

Carry a row sheet (greenhouse map) and flagging tape so you can mark and record any areas for future spot treatments or BCA release. If BCAs are released it is useful to record the date on the flagging tape so the efficacy of the treatment can be observed. Only remove flags once the pest is controlled.

Scouts should carry a small clear container to contain any unknown pest/disease for further identification. It can be useful to keep a caterpillar alive to complete its lifecycle as moths are often useful in species identification.

3.8 Appendix 6 – Resources for side projects



Technote

TomatoesNZ

Off-label use of Benevia®, Mainman®, Movento OD®, Calypso® for early season whitefly control in Greenhouse Tomatoes

Key Information

- Benevia®, Mainman®, Movento® OD, and Calypso® may provide whitefly control early in the growing cycle before releasing the biological control, *Encarsia formosa*.
- Preharvest intervals are recommended.
- These four insecticides are each in a different mode of action group, providing additional options for insecticide resistance management.
- Make no more than two applications of each product to greenhouse tomatoes.
- Observe the maximum per hectare application rates for Benevia®, Mainman®, and Movento® OD.

Background

To assist growers to access and use new insecticides, Tomatoes NZ carried out greenhouse trials through the A Lighter Touch programme to calculate appropriate pre harvest intervals (PHIs) for Benevia®, Mainman®, Movento® OD, and Calypso® in greenhouse tomatoes.

There are no registered use claims for Benevia®, Mainman®, Movento® OD, or Calypso® in greenhouse tomato crops.

Benevia® and Movento® OD are registered for use on field tomatoes, and MRLs have been set by MPI for both products in tomatoes. However, because the label is restricted to field tomatoes, trials were needed to establish an appropriate PHI for greenhouse tomatoes to meet the New Zealand MRLs for Benevia® and Movento® OD.

Mainman® and Calypso® have no registered uses for tomatoes, and no MRLs have been set for tomatoes. However, off-label use is permitted in New Zealand, as long as the default MRL of 0.10 mg/kg is not exceeded.

This Technote summarises the results of this research, so that growers know what use pattern of Benevia®, Mainman®, Movento® OD, and Calypso® will result in residues that do not exceed the New Zealand MRLs.

The PHIs for all of these products are relatively long, and it is suggested that the most suitable timing for their use is for whitefly control early in the growing cycle before releasing the biological control, *Encarsia formosa*.

Description of the insecticide products

Benevia® is a Group 28 insecticide, containing 100g/litre cyantraniliprole in the form of an oil dispersion. It has a field tomato label claim for control of Tomato potato psyllid, potato tuber moth, green peach aphid, and tomato fruit worm. Benevia® enters larvae mainly by ingestion, but also by contact, resulting in rapid cessation of feeding, but death may not occur for 3-6 days, depending on pest species.

Mainman® is a Group 29 insecticide, containing 500g/kg flonicamid in the form of a water dispersible granule. Mainman® has systemic and translaminer activity, controlling target pests by contact and ingestion by causing rapid and irreversible cessation of feeding. Death may take several days to occur. The product has a label claim for aphids and Tomato potato psyllid in potato crops.

Movento® OD is a Group 23 insecticide containing 150g/litre spirotetramat in the form of an oil dispersion. Movento® OD has systemic activity (both xylem- and phloem-mobile) and is registered for control of Tomato potato psyllid in field tomatoes and green peach aphid in potatoes.

Calypso® is a systemic Group 4 insecticide containing 480g/litre thiacloprid in the form of a suspension concentrate. It has label claims for the control of armoured scales, bronze beetle, codling moth, mealy bugs, Froggatt's apple leafhopper and Fuller's rose weevil in apples, thrips in avocados, armoured scales in kiwifruit, and thrips in nectarines and peaches.

Guidance for Off-label Use of Benevia®, Mainman®, Movento® OD, and Calypso®

Growers should follow NZGAP's Guideline for Growers whenever using agrichemicals off-label (https://www.nzgap.co.nz/NZGAP_Public/Growers/Guidelines.aspx).

Benevia®, Mainman®, Movento® OD, and Calypso® may be used off-label, however growers should check with their customers (supermarkets, marketing companies etc.) in case they have rules against off-label use.

Product	Rate	Use pattern and controls
Benevia®	33 ml Benevia®/ 100 litres of water.	• Maximum of 2 applications with a minimum spray interval of 7 days (refer to the Benevia label regarding specific pests). • Apply the final spray no later than 28 days before harvest. • DO NOT exceed the application rate – the maximum application rate[1] is 500ml Benevia® (50g active ingredient) per hectare, per application. • Observe label directions regarding honeybees.
Mainman®	11g Mainman® / 100 litres of water.	• Maximum of 2 applications with a minimum spray interval of 7 days. • Apply the final spray no later than 35 days before harvest. • DO NOT exceed the application rate – the maximum application rate[1] is 160g Mainman® (80g active ingredient) per hectare, per application.
Movento® OD	37ml Movento® OD /100 litres of water.	• Maximum of 2 applications with a minimum spray interval of 7 days. • Apply the final spray no later than 35 days before harvest. • DO NOT exceed the application rate – the maximum application rate[1] is 560ml Movento® OD (84g active ingredient) per hectare, per application.
Calypso®	30ml Calypso® / 100 litres of water.	• Maximum of 2 applications with a minimum spray interval of 7 days. • Apply the final spray no later than 35 days before harvest.

[1] *Maximum application rate as established by the Environmental Protection Authority.*

Residue testing

The residue trial for this project was carried out in one greenhouse on a single cherry tomato variety. Based on the results of these trials, we expect that a final spray application of Benevia® 28 days before harvest, and Movento® OD, Mainman®, and Calypso® 35 days before harvest will result in any residues being below the applicable New Zealand MRL. However, we still recommend that growers regularly undertake residue testing to ensure that their fruit remains compliant with the required MRLs. We also recommend that crop safety tests are carried out by growers on a small crop area before wider application.

Any residue exceeding the relevant MRL should be notified to Tomatoes NZ so that this information can then be added to the knowledge base.

This Technote is intended to provide guidance only. While every effort has been made to ensure the information in this report is accurate Tomatoes NZ does not accept any responsibility or liability whatsoever for any error of fact or omission in preparing and publishing this document. Tomatoes NZ also does not accept any liability in respect of loss or damage arising from the use of this information.