



# A LIGHTER TOUCH

#### Agroecological approaches to insect pest control in perennial crop systems

Establishing floral resources for improved biological control



#### PART 3: MANAGEMENT AND EVALUATION OF BENEFICIAL PLANTINGS

The aim of this project is to develop an understanding of how overall biodiversity and specific natural enemies can be enhanced within orchard and vineyard environments (using citrus as the model crop production system) to better manage insect pests. By enhancing the abundance of beneficial insect predators and parasitoids, the use of agrichemicals could be reduced, resulting in a more sustainable approach to insect pest management. The case study location for this project is on two citrus orchards in Gisborne.

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# Introduction

The aim of this project is to develop an understanding of how overall biodiversity and specific natural enemies can be enhanced within orchard and vineyard environments (using citrus as the model crop production system) to better manage insect pests. By enhancing the abundance of beneficial insect predators and parasitoids, the use of agrichemicals could be reduced, resulting in a more sustainable approach to insect pest management. The case study location for this project is on two citrus orchards in Gisborne.



The approach taken to enhance the abundance and diversity of naturally occurring beneficial insects as biological control agents (BCAs) will be through the establishment of beneficial plantings that provide **S**helter, **N**ectar, **A**lternative non-target insect prey, and **P**ollen (**SNAP**) for the beneficial insect species. This is broadly described as 'conservation biocontrol'<sup>1</sup>

The project involves the establishment of beneficial plant species in the orchard via planting interrow, intra-row (under canopy), and annual flower strips. The practical approaches to establish, manage and monitor these plantings will be trialled over two years to ensure methodologies are 'fit-for-purpose' across all types of fruit production.

The information in this report forms part of a 3-part toolkit that records the three phases of the project: (1) **establishment** of the beneficial plantings, (2) insect **monitoring** within the crop and beneficial plantings, and (3) **management and evaluation** of the beneficial plantings and insect monitoring data.

This module covers the third phase –management and evaluation and provides a 'how-to' guide of what should be considered when establishing and managing beneficial plantings in an orchard.

Two citrus orchards in Gisborne are used as case study examples to showcase the insights and learnings of this floral resourcing project, but they equally apply to any perennial crop, e.g., vines, pip, stone fruit, etc.

<sup>1</sup> <u>https://en.wikipedia.org/wiki/Biological\_pest\_control#Conservation</u>

# What do we mean by management?

The management process is a cycle of continuous improvement that involves the three steps of planning, implementing, and reviewing.

The **Planning** phase should begin well before any activity occurs in the orchard. The planning phase identifies what activities need to happen and how and when these activities should occur (e.g. deciding what seed mix is suitable, when and how seed should be sown, when scouting should start).

The **Implementing** phase is the execution of the planned activity (e.g. ground preparation, sowing seed, weeding, mowing, scouting).

The **Review and Revise** phase involves the process of reviewing all activities carried out to look at what was successful, for example, how well did the understory establish? What information has been collected during scouting? The information collected during the monitoring phase is used to feed back to assist with future planning and the cycle continues.



In terms of a management plan, we look at what we've *planned* and *implemented* and then we *review*, which may provide ideas for improvement to feed back into the next planning phase (*revise*).

This Management and Evaluation toolkit uses this management cycle and the activities on the ground in the Gisborne citrus orchards to illustrate a pathway to establish biodiverse plantings in an orchard and the decisions and considerations at various stages. While citrus is used as the case study the same principles, insights and learnings can be applied to other perennial fruit crops such as summerfruit, persimmons, kiwifruit and passionfruit.

# **Checklist for management of beneficial plantings**

- Seed mix. Select species suitable for your region.
- Soil conditions. Understanding soil conditions and climate is a key consideration to decide when ground preparation and planting should occur.
- Ideally plan planting for Spring or Autumn although this depends on location. The soil conditions, moisture levels, and temperature are critical to determining how successfully seeds germinate and grow.
- Estimate when a suitable weather window might occur so that the ground can be prepared, for example, herbicide sprays to kill off the existing ground cover, mowing, or use of cultivation to prepare the ground in advance of sowing.
- Start small. Plant a small area of orchard to start with. Understand what annual and flowering plant species are most suitable for your situation, how well they grow and how to manage them. For example, annual plants can be managed by mowing, part mowing of planted annuals can be an effective way to extend flowering.
- On't just plant and leave. The understory is like any other part of the orchard, it needs monitoring and active management.
- Weed control is critical be proactive to control weeds. Weeds will outcompete understory annual and flower species in the right conditions. If weeds are getting away, then consider grazing or mowing to control weed height and prevent weed flowering and seeding.
- Have a scouting plan. Are commercial crop scouts available?
  - It may take several attempts to grow the beneficial plantings. Be prepared to resow and try again.



# Planning

At the onset of this project the aim was to trial agroecological approaches for insect pest control by establishing beneficial plantings in two citrus orchards located in Gisborne. The objective was to enhance the abundance of beneficial insects to achieve enhanced biocontrol of insect pests. Our plan to achieve this objective was first to work out how to establish the understory.

The plant species were initially selected by identifying the main pests, then searching the literature for their BCAs and conservation biocontrol approaches that will boost the beneficials. This work is summarised by Merfield and Shields (2021) https://merfield.com/research/2021/ agroecological-pest-management-in-citrus-2021-merfield-shields.pdf

The initial stage of establishing understory plantings, including seed selection, the equipment used for ground preparation, and sowing seed, are provided in more detail in a previously published module; Part 1. Establishment. This module can be downloaded from the A Lighter Touch website (https://a-lighter-touch.co.nz/establishing-floralresources-for-improved-biological-control/). A summary of steps to establish understory plants in an orchard can be downloaded from https://a-lighter-touch.co.nz/wp-content/ uploads/2022/06/ALT-Part-1-Steps-Summary-WEB.pdf

#### During our planning to establish the understory plantings, we considered:

- Seed mix and plant species selection.
- Soil conditions if the soil is too wet machinery will compact the ground.
- Timing. Spring plantings in northern areas (eg. Gisborne) usually means high weed competition particularly C4 grasses which can quickly smother the cover crop species. Autumn plantings in southern areas (e.g. Otago) may have a very narrow window of opportunity as frosts start early.
- Existing groundcover grassy sward or bare ground?
- Weediness is a herbicide spray (e.g. glyphosate) required to remove weeds?
- Availability of machinery to prepare the interrow and understory areas – are cultivators, power harrows, mowers available in the region to use? Are contractors available?
- Approach to sowing seed is suitable equipment available to disc drill, compost spread and roll or hand spread?

Part 3: Management and evaluation of beneficial plantings

### Our plan to **manage the understory plantings** was to:

- Control weed species to allow desired species to establish well;
- Mow only when necessary and only after flowering;
- Resow annual flowering species after flowering completed;
- Terminate cover crop with herbicide or by roller crimping this is a special roller with blades that crimp but does not cut the stems;
- Scouting collect pest and beneficial insect data and analyse this against cover crop growth stage.



#### Our planning for **scouting** was to:

- Obcide how to resource scouting. Are commercial crop scouts available?
- Check the scouts are trained and know what pests and beneficial insects to look for.
- Develop a plan for scouting and use the monitoring toolkit for guidance.
- Check that the scouts have all the necessary tools e.g sweep nets, hand lens, record sheets.
- Use Excel® to collate and analyse the scouting data.
- Decide what could be interpreted from the data, for example presence/absence of beneficial insects.

We used commercial crop scouts, but another option is to carry out your own scouting. The process of scouting and the types of beneficial insects are recorded in the previously published module; Part 2. Insect monitoring of perennial crops. This module can be downloaded from the A Lighter Touch website (https://a-lighter-touch.co.nz/insect-monitoring-ofperennial-crops/).



# Implementing

We documented the activities in the two Gisborne citrus orchards, how the planted areas were established and managed and what issues were encountered. The purpose is to provide realworld examples and some of the learnings.



#### **Gisborne case study orchards**

Braemark Vineyards – Bushmere Road (GPS 38°38'02.6"S 177°55'35.5"E), growing Afourer mandarins, and IKO Orchard – Waingake Road (GPS 38°42'15.79"S 177°50'24.04"E), growing Washington navels. The two orchards are over 11.3km apart by direct line of sight. Braemark orchard is situated on the Waipaoa river flats approximately 9 km from central Gisborne. IKO Orchard is situated on the Te Arai river flats, located further inland and receives less coastal weather influence.



Braemark Vineyards – Bushmere Road



IKO Orchard – Waingake Road

### **Gisborne case study timeline**





2021

#### 19th - 22nd November

The first understory plantings were sown in the two orchards in mid-November 2021. Braemark Orchard was sown in the inter-row with pasture species, the intra-row areas were sown with annual flower species using a combination of compost and hand spreading seed. In the IKO orchard 4 rows of pasture species were sown and every 5<sup>th</sup> row an annual flower strip planted.

For both orchards a vineyard seeder was used to sow seed.

2022



#### **Crop scouting**

The crop scouting data was collected by field scouts over a 4-month period from January 2022 to April 2022, collated into an Excel® spreadsheet, and sent to Plant & Food Research for analysis. The prevalence of pest and beneficial insect species were monitored in the 'Agroecology' blocks (with beneficial plantings) and untreated control blocks (without beneficial plantings).





#### 28<sup>th</sup> January

Flowering plants at knee height in the IKO orchard. Establishment of the understory appeared more successful than Braemark orchard. Sheep were run through the IKO orchard after drilling and the weather was favourable with rain following planting.





Flooding in IKO orchard

#### 23rd March

A severe weather event hit Gisborne. The equivalent of a month of rain (>80mm) fell in just 7 hours.

#### April

In IKO orchard the pasture rows were mown. The pasture appeared very weedy. Spraying out the worst parts was considered. Most of the broadleaf mix (lucern, white clover, persian clover, plantain) had germinated.

#### 27<sup>th</sup> April

The interrow areas in Braemark orchard were resown. The intra-row plantings were sown early Spring.

#### 24<sup>th</sup> August

For both orchards it appeared that while the grasses established, the broadleaf species (clover etc) did not. As a result, the ground cover was taken over by a number of weeds.

It was decided to re-sow as soon as the weather was suitable.

#### 5<sup>th</sup> December

Braemark Orchard Block cultivated and drilled with clover/grass mix down each row. Plan to sow buckwheat /floral mix every 4<sup>th</sup> or 5<sup>th</sup> row at Braemark and IKO orchard.

#### February

Cyclone Gabrielle 13<sup>th</sup> - 14<sup>th</sup> February 2023 and after effects of this severe weather event. State of Emergency declared in Gisborne and Hawkes Bay region. Communications, powers and roading networks all significantly affected.

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2023



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#### Braemark orchard

The understory was sprayed off to reset prior to re-sowing. The plan was to use either a vicon + chain harrow approach, or a contractor with a power harrow drill seeder combination. Ground conditions were still wet. Afourer mandarin harvest was approximately 6 weeks away.

#### IKO orchard

The navel oranges were harvested later this week and into the next week. The plan was to prune trees following harvest and then re-sow the understory using power harrow and drill. Every 4<sup>th</sup> or 5<sup>th</sup> row was replanted with the flower species mix.



Cultivation and resowing in IKO orchard

#### 27<sup>TH</sup> October

Cultivation and resowing of the IKO orchard.

#### **16<sup>™</sup> January** IKO Orchard

The flower species mix was sown in. The area to be resown was closely mown and then seed drilled directly into the mown strips. Prior to mowing, sheep had been used to take the grass cover down. Herbicide (Puma®S - HRAC MOA 1) was used to knock out the summer grass. By removing the competing grass, and by grazing sheep and mowing, the flower species will quickly grow through.



Resowing the understory in IKO orchard

### Our activities during the implementation period included:

- Weed control. Weeds selectively removed where weed problems were observed (e.g. Barnyard grass);
- Mowing. The understory floral plantings were mowed only to allow worker entry and activity in the orchard;
- ✓ Resowing the understory, as necessary;
- Crop scouting for insects (pests and beneficial species) being regularly done.

Over the period of this project from November 2021 to February 2023 the Gisborne region has experienced some extreme weather events. Over the 16-month period, an excess of 200mm/month of rain was recorded for five of those months.

The excessive and persistent rain, and moist soil conditions caused delays to ground preparation and planting in the orchards. Conversely once seed had been sown, the lack of rain resulted in poor germination and competition from weeds.





Ensuring seed is well mixed before resowing

Early growth of the understory



Source: Gisborne rainfall data sourced from Gisborne District Council (<u>https://www.gdc.govt.nz/environment/maps-and-data/rainfall-data</u>). \*Cyclone Gabrielle – no records 14-17<sup>th</sup> February due to power disruption. It is estimated that up to 460mm rain fell during February 2023.

# **Review** and revise

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This phase involved reviewing the overall project including evaluating how well the beneficial plantings established, and analysing the data that was collected from scouting activities.

The information collected during the review phase was used to feed back to plan future planting activities in the orchards.





#### Our review looked at:

- How we prepared the orchard for sowing – how successful was this approach?;
- The process followed to establish the cover crop.
- ✓ The cover crop species used;
- When we mowed;
- Whether or not to resow the annual flower species;
- Whether the scouting plan was effective and what data was collected;
- Whether the scouting data was suitable and could tell us anything about the benefical insects in the orchard.



**Orchard ground preparation** was a key part of successfully establishing beneficial plantings. The existing grass cover was sprayed off using a Roundup® herbicide spray. This was effective at removing the immediate weed competition but did not remove ungerminated weeds present in the soil. The length of time between spraying off and sowing seed was important. Longer than 2 weeks allowed new weeds to germinate and outcompete the planted seed.

The method of **sowing seed** was a crucial step. For both orchards a direct drill approach using a vineyard seeder was used to sow seed. While partially successful, the seed germination was patchy which may also have been down to timing and soil moisture levels. Other options to sow seed in future plantings could be by using light cultivation pre-drilling. The aim is to achieve good seed-to-soil contact with any method used.

- Sow early in spring to avoid summer grass germination; don't' go late because of weed competition.
- Use a stale seed bed to reduce weed competition.
- Resowing technique mowing before resowing by direct drilling in seed was trialled.
- Terminating cover crops –options that were considered included spraying off with herbicides and crimping.

The **scouting** protocol was based on a routine crop monitoring approach that looked at 10 randomly selected trees on a fortnightly basis. At each tree, a visual assessment was conducted at each of five randomly selected sites of the tree canopy and the incidence of pest and beneficial insects was recorded.

Our review of the scouting data suggested that future monitoring should include counts of species rather than just presence/absence records as it was difficult to draw any conclusions from the data. Monitoring for beneficial species in the crop and also in the understory planting areas in the interrow, would also provide a better picture of beneficial populations within the orchards.

- The scouting protocol was reworked following the first round of monitoring to improve the abundance data collected.
  The scouting protocol was adjusted to include placement of sticky traps and use of sweep nets to sample for beneficial insects in the floral plantings in addition to visual count monitoring of the crop.
  This protocol was fed into next season's monitoring plan.
- A training session was held with scouts to demonstrate the new protocol and methods.
- New equipment such as sweep nets and sticky traps were purchased.
- The Excel® spreadsheet was adjusted to record the extra count data being collected.



# **Evaluation**

The data collected from the scouting was recorded by the scouts onto a field scouting sheet. This data was entered into a Microsoft® Excel® spreadsheet for analysis.

As the data recorded was presence/absence of beneficial insects the analysis compared the proportion of beneficial or pest species present.

Scouting data reports the activity of pest and beneficial insects in the orchard. Orchard managers can use this information to make decisions around pest control and when an intervention, such as application of an insecticide spray is needed.

Counting beneficial insects and not just pests provides an holistic view of the biodiversity in the orchard. Using this information to inform management decisions forms part of an integrated pest management (IPM) approach. Enhancing these beneficial insect populations through plantings to provide 'SNAP' is an agroecological approach for pest control. Scouting sheets

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Field scouting sheet for beneficial insects



Proportion of trees with citrus pests or beneficial insects present at each monitoring date. Graph courtesy of Plant & Food Research.

one: 6/4/22



### Resources

### 7.1 Photo record of Gisborne citrus orchards

### **Understory Planting** Citrus - Gisborne



### **Time series of understory establishment** Braemark Orchard & IKO Orchard





Part 3: Management and evaluation of beneficial plantings



### 7.2 Resources

Chhagan A, Bellvé A. June 2022. A lighter touch (ALT): Agroecological approaches to insect pest control in perennial crop systems: Preliminary evaluation and analysis of crop monitoring data. A Plant & Food Research report prepared for: Horticulture New Zealand. Milestone No. 95176. Contract No. 40439. Job code: P/351003/01. PFR SPTS No. 22651.

González-Chang, M., Tiwari, S., Sharma, S. and Wratten, S. D. 2019. Habitat Management for Pest Management: Limitations and Prospects. Annals of the Entomological Society of America. 112, 4: 302-317. DOI: 10.1093/aesa/saz020.

Hartley, M.J., A. Rahman, K.C. Harrington, and T.K. James. 2000. Assessing Ground Covers in a Newly Planted Apple Orchard. New Zealand Plant Protection 53 (August 1, 2000): 22-27. Accessed February 16, 2023. https://journal.nzpps.org/index.php/nzpp/ article/view/3643.

Jonsson, M., Wratten, S., Landis, D., Tompkins, J.-M. and Cullen, R. 2010. Habitat manipulation to mitigate the impacts of invasive arthropod pests. Biological Invasions. 12, 2933-2945. DOI: 10.1007/s10530-010-9737-4.

Merfield, C. N. & Shields, M. W. 2021. Agroecological pest management in citrus. Lincoln: Merfield Agronomy Ltd. https://merfield.com/research/2021/ agroecological-pest-management-in-citrus-2021merfield-shields.pdf.

Merfield, C. N. 2022. Integrated weed management in Citrus. Growing citrus in New Zealand. Citrus New Zealand. 36p.

Shepherd, T.G.; Ross, C.W.; Basher, L.R.; Saggar, S. 2000: Visual soil assessment, Volume 2. Soil management guidelines for cropping and pastoral grazing on flat to rolling country. horizons.mw & Landcare Research, Palmerston North. 44p.



### 7.3 Useful websites

BiofruitNet (https://biofruitnet.eu/). Website of useful resources supporting organic fruit production in Europe. Resources on use of cover crop in orchards: https://biofruitnet.eu/wp-content/ uploads/2022/12/79\_PA\_BIOFRUITNET\_Final.pdf

https://biofruitnet.eu/wp-content/uploads/2022/03/ BIOFRUITNET\_Webinaire\_CoverCrops\_Mars2022\_web\_ definitivo.pdf

CORDIS (Community Research and Development Information Service) EU Research Results. Agroecology: research for resilient, sustainable, climate-, ecosystem- and social-friendly farming systems. <u>https://cordis.europa.eu/article/id/442635-</u> agroecology-research-for-resilient-sustainable-climateecosystem-and-social-friendly-farming\_

SARE (Sustainable Agriculture Research and Education). Cover crops information and beneficial insect management.

Cover crops: <a href="https://www.sare.org/resources/cover-crops/">https://www.sare.org/resources/cover-crops/</a>

Beneficial insects: <u>https://www.sare.org/wp-content/uploads/</u> <u>Manage-Insects-on-Your-Farm.pdf</u>

Michigan State University scientists have evaluated orchardscale ground cover experiments in established commercial orchards and in a new tart cherry orchard at the Northwest Horticultural Research Station.

https://www.canr.msu.edu/ipm/uploads/files/ E2890CherryReport.pdf



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