

# **SeasonReview2023**

Stuart Dykes

2024-07-11

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# Preface

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# **1 Introduction**

## **2 Cyclone Gabrielle and resilience**

Author: Stuart Dykes and Matt Saunders

### **2.1 Introduction**

#### **2.1.1 Hawkes Bay regional context**

On 14<sup>th</sup> February 2023 Cyclone Gabrielle hit New Zealand with record rainfall and flooding. Hawke's Bay was one of the hardest hit regions leaving many communities and businesses damaged or destroyed.

16% of the Hastings District was flooded. Initial estimates (Selvaraj, Sadhvi (2023)) suggest approximately 1,600 homes were flooded across Hawke's Bay, some with up to seven metres of water. Across the region over 1,000 properties were stickered (i.e. unable to be either temporarily or permanently inhabited). Homeowners in severely impacted areas had to wait several months for central and local government to make decisions around the future use of their land.

28 days after Cyclone Gabrielle, the State of Emergency was lifted in Hawke's Bay. The region then entered a phase of recovery and rebuilding, which required a significant investment from industry, iwi, central and local government. Estimates put the final expected national rebuild cost in excess of NZD13 billion. Fundamental to the recovery is the need for regionally-led leadership and direction. Local leaders have worked together to develop a Hawke's Bay Cyclone Gabrielle Regional Recovery Framework to provide a structure for recovery efforts. Cyclone Gabrielle has exposed the fragility of the region's critical infrastructure, so underpinning the recovery activities will be the need to ensure future resilience against catastrophic events at every level.

#### **2.1.2 Environment**

Cyclone Gabrielle is the most significant weather event on record with between 250 – 400mm rainfall recorded across the region. Slash, debris and soil slowed the flow of rivers which in turn breached stop banks, inundating surrounding areas with flood waters. It is only the third time in New Zealand's history a national state of emergency has been

declared. Climate change and the resulting warming oceans intensified the cyclone and increase the likelihood of future catastrophic weather events. As a region, a better understanding of the environmental impacts of climate change and what skills are needed to deliver sustainable solutions and risk mitigations need to be explored. Environmental resilience will be a key focus of the recovery.

### **2.1.3 Horticulture**

Horticulture remains vital to the Hawke's Bay economy. Initial estimates put orchard losses from the cyclone at approximately 30% for all apple orchards and other crops, but with other organisms and disorders latently affecting non-damaged trees, this number has risen beyond those trees directly impacted. The supply of replacement trees is estimated to be below the required numbers, with commercial nurseries predicting it may take up to five years to meet demand caused by damage due to cyclone.

## **2.2 Cyclone Gabrielle impact on Rockit™ apple orchards**

In January 2023 the total canopy hectares of productive (i.e. producing) Rockit™ orchards was xxxx hectares with an additional yyyy hectares of new orchards yet to produce a commercial crop. When cyclone Gabrielle arrived on the 13th February the flood and consequential silt inundation caused extensive damage to a number of orchards that were close to rivers and low lying areas. Figure 2.1 shows a map of Hawke's Bay immediately after cyclone Gabrielle with areas of flooding and silt inundation; overlaid is all the productive Prem A96 orchards at the time of the cyclone.

Figure 2.1 shows a map of Hawkes Bay including the post cyclone Gabrielle distribution of silt and flooding. Overlaid are the locations of all producing Rockit™ apple orchards. The most striking feature of the map is the silt inundation between the Ngaruroro and Tutaekuri rivers. This was a result of the northern and southern stop banks failing for the Ngaruroro and Tutaekuri rivers respectively, affecting a large area between those two rivers, most significantly: Pakowhai, Waiohiki and Korokipo. There are four large Rockit™ apple orchards in the Korokipo catchment.

The Tutaekuri river stop banks also failed further upstream in the Puketapu and Moteo Pa areas causing extensive damage to four Rockit™ apple orchards. A subsequent decision was made not to replant one of these orchards which was catastrophically damaged.

Extensive damage also occurred in the Omaha sector where flooding destroyed more than 60% of a single block with less than 34% remaining from the pre-cyclone canopy area. In total

As can be seen from Figure 2.1, apart from the aforementioned damage the block standing, however production was affected as only apple 30cm above the flood line were harvested to avoid any ongoing issues with food safety (predominantly Listeria).

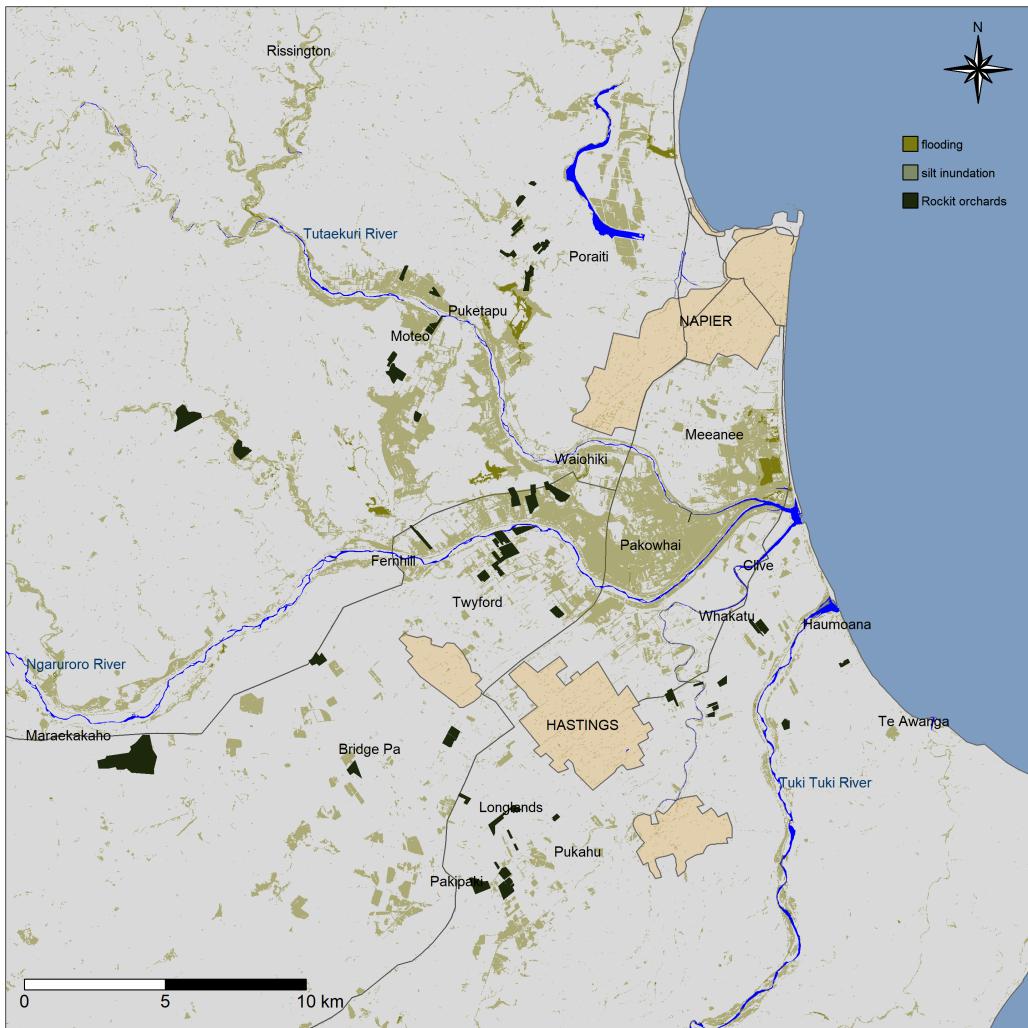


Figure 2.1: Post cyclone Gabrielle map showing: flooding, silt inundation and all productive Prem A96 orchards overlaid

### 2.2.1 Weather

To give the cyclone some perspective the rainfall and wind data is reviewed below for the weather stations that are installed on Rockit™ apple orchards. The exception being

the Puketapu data which was sourced from the Met Services weather station available through the NZ Apple and Pears database. The cumulative and hourly rainfall are shown graphically for Rockit™ apple orchard sectors in Figure 2.2 and Table 2.1. Over the duration of the cyclone the most rain fell in the Pukehamoamo, Puketapu and Omaha in-land areas (refer to Figure 2.1) with cumulative rainfalls of 269, 248 and 226mm respectively. South of Hastings the rainfall was less in volume with Ngatarawa, Bridge Pa and Whakatu delivering 145, 118 and 117mm of rain respectively over the same period. Gisborne saw 184mm of rain fall over the same cyclone duration which was above the Hawke's Bay mean cumulative rainfall of 178mm.

Table 2.1: Maximum cumulative and amximum hourly rainfall for 11 regional Rockit™ apple growing sites during cyclone Gabrielle

weather station site	rainfall / mm	
	cumulative	hourly
Pukehamoamo	268.6	34.2
Puketapu	248.3	21.7
Omahu	226.8	33.2
Gisborne	184.6	20.4
Maraekakho	170.2	16.4
Mangatere	163.0	18.2
Paki Paki	159.6	17.4
Haumoana	159.2	19.8
Ngatarawa	145.0	16.6
Bridge Pa	117.8	10.4
Whakatu	116.6	16.8

Wind is typically measured by looking at both wind speed and the azimuthal direction. A convenient way to visualise the distribution of windspeed and direction over a period is through a windrose diagram. This is presented in Figure 2.3 for the five weather stations with wind sensors installed. The prevailing wind direction was easterly for Gisborne and south-east easterly for the Hawke's Bay region. The rose indicates that there was very little variation in the wind direction over the cyclone duration.

Figure 2.4 shows that the wind sensor in Gisborne failed just after 22:00 on the evening of 13th February. Winds were blowing around 60 and gusting above 100 km/hr. At the peak of the cyclone (estimated to be around 22:00 on Monday 13th February), wind-speeds of 80 gusting to 132 km/hr were recorded at the Mangatere station. In all cases the wind gusts were approximately double the measured wind speeds.

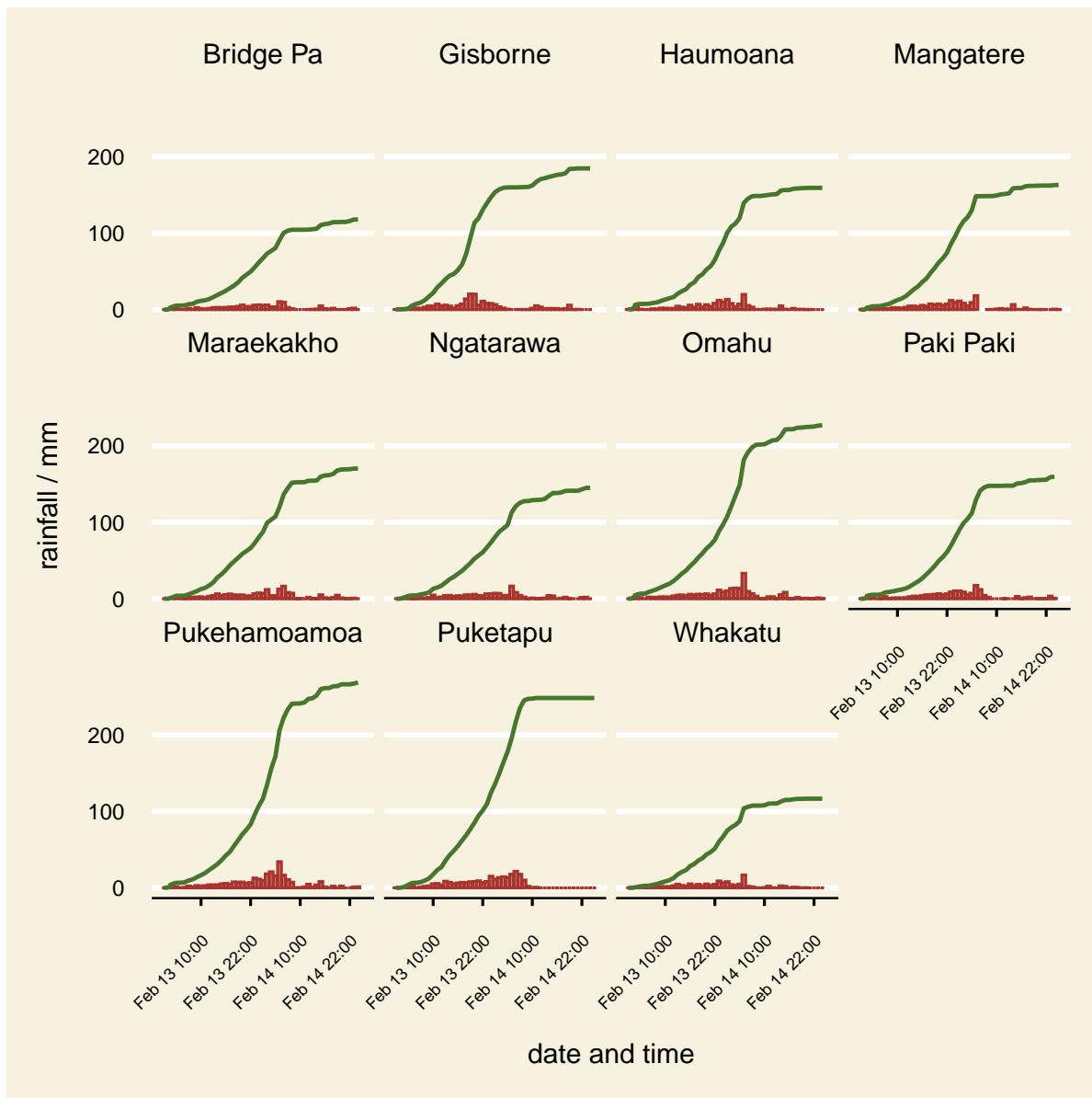


Figure 2.2: Cumulative and hourly rainfall over the 36 hours of cyclone Gabrielle for 10 weather stations located on Rockit™ apple orchards. The Puketapu site data is obtained from an independent MetService site accessed through NZAPI website

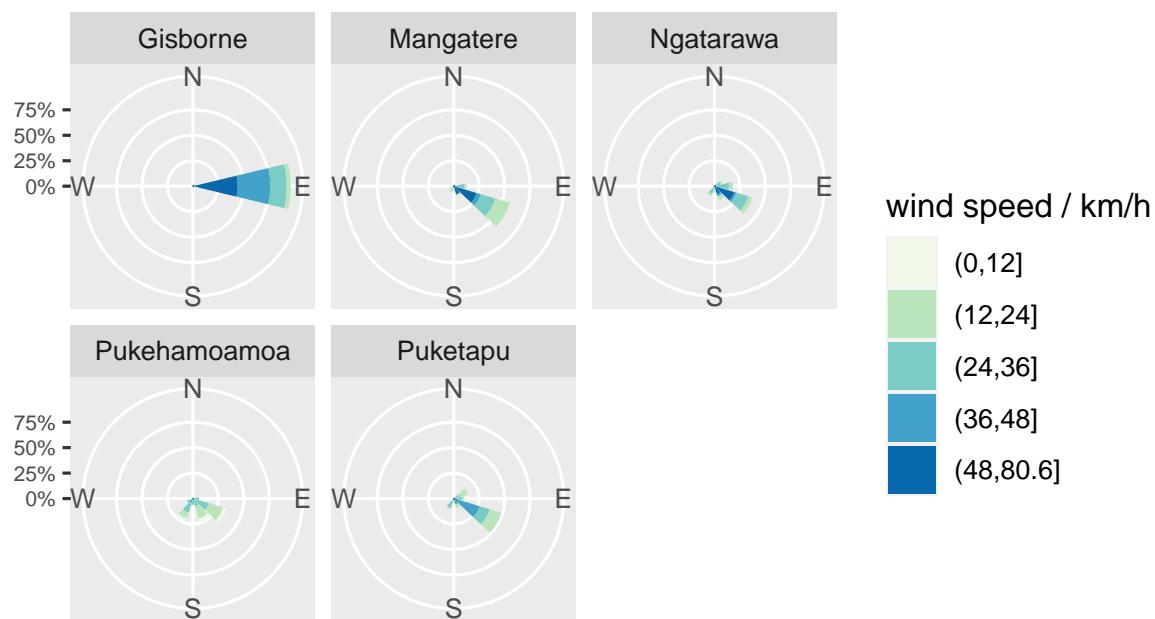


Figure 2.3: Windrose showing the distribution of wind-speed and direction over the duration of cyclone Gabrielle. The wind-speed is given in km/h units

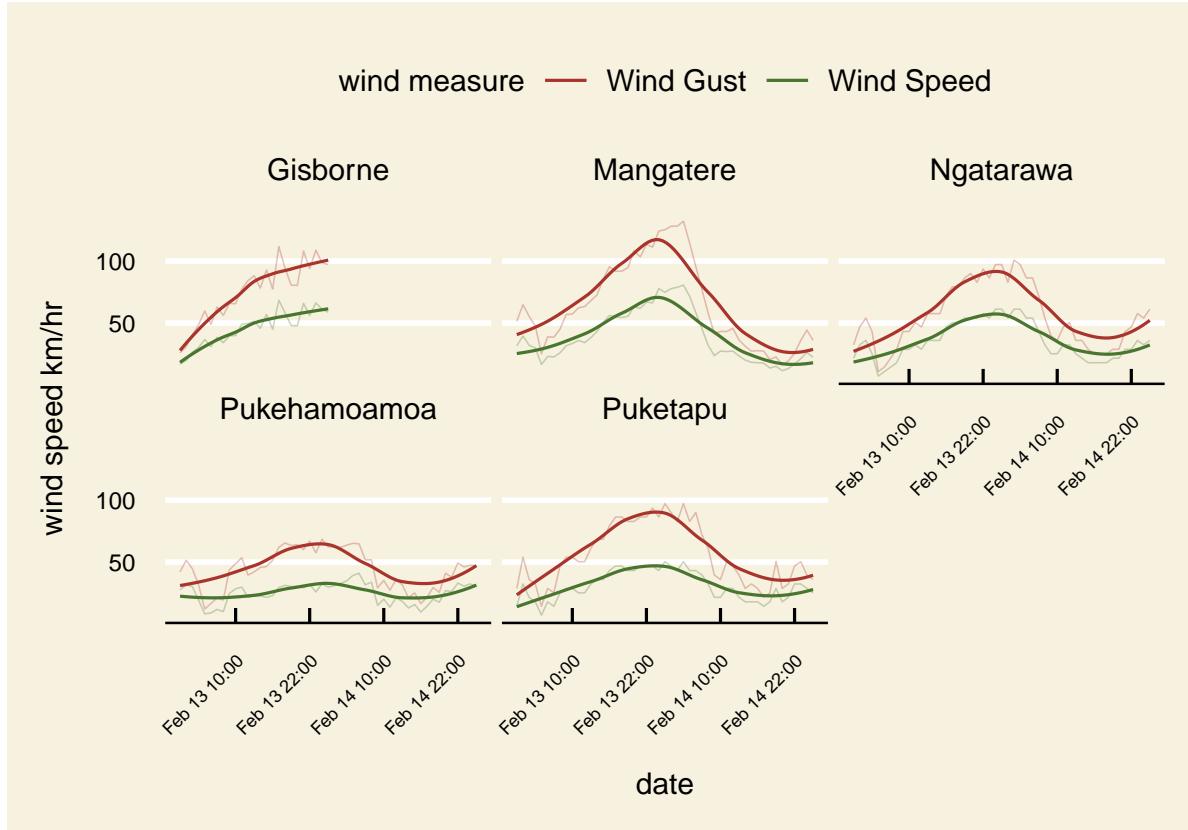


Figure 2.4: Wind and gust speeds as a function of time over the duration of cyclone Gabrielle. The wind-speed is given in km/hr units

## **2.2.2 Immediate actions post cyclone**

The initial triage began on the afternoon of 14th February by contacting all staff and verifying access to orchards. Initially no access was available for a number of blocks predominantly around the Moteo Pa, Swamp Road, Puketapu and Puketitiri Road areas. A number of bridges had been destroyed including main bridge between Moteo Pa and Puketapu, restricting all access between these sites that were, hitherto, part of the same sector.

Where river stop banks had failed (this happened on both the Ngaruroro and Tutaekuri rivers), the water flowed into adjacent land areas with considerable momentum carrying silt and debris through orchards and vineyards. The effect was to knock over the infrastructure (posts and wires) and trees. Moreover equipment such as filled bins and reflective mulch were picked up and taken down stream. Rockit™ apple bins were collected more than four kilometres from the nearest orchard. What remained after the flood waters subsided was a thick layer of silt (more than one metre in some cases), debris brought from upstream (often termed slash) and debris from the orchard (posts, wires, reflective mulch field bins and also orchard mobile plant).

For affected orchards where access was possible the immediate and urgent remediation was to remove the flood water where

# **3 seasonal climate summary**

Authors: Stuart Dykes & Tim Channing Pearce

## **3.1 Introduction**

Rainfall, temperature, and solar radiation are the major climatic factors affecting apple growth and yield (Li et al. 2018; Fujisawa and Kobayashi 2011). As stated in Chapter 1 the 2022/2023 growing season has been challenging in terms of the effects of the climate, culminating in the devastating effects of cyclone Gabrielle.

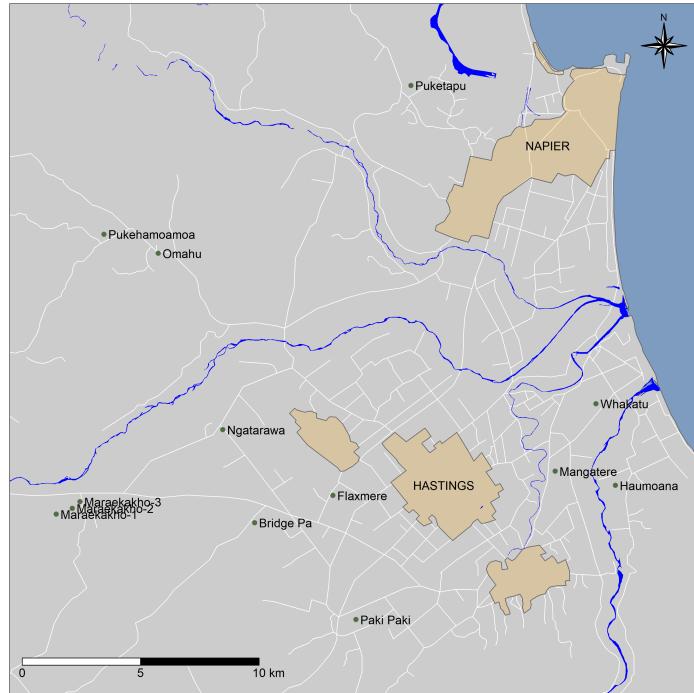
In general, seasonal performance can be attributed to a number of factors such as:

- climate (e.g. rainfall, temperature, wind)
- management decisions (e.g. pruning, spray programme, thinning philosophy/execution and harvest manipulations)
- disease pressure (e.g. black spot, ALCM)
- Fruit maturity at harvest
- post-harvest conditions (storage) and management decisions

In terms of the climate, the effects can be categorised in two ways: long term trends and major events. The first part of this chapter will review some of the long term trends and the second part, which focuses on cyclone Gabrielle, is covered in Chapter 2.

## **3.2 Sources of climate data**

In 2020 Rockit began a project to place climate station in close proximity to orchards. To date 13 stations have been deployed and are active (one station was destroyed with the orchard), which gives RGL unique and local insight into the micro-climates and their influence on the growth of Rockit™ apple trees. The oldest stations have only been in place for three years at the time of this report in some cases it is difficult to compare the 2022/2023 with prior seasons and assess trends. To anonymise the exact location of the weather stations, the geographic region will be stated rather than the orchard name.



(a) Hawkes Bay



(b) Gisborne

Figure 3.1: Active Metris weather station locations providing data for the following analysis

Figure 3.1 shows the location of the Rockit™ apple Metris weather stations which are used for analyses in this chapter.

A number of key climate metrics are ubiquitous in the literature (Logan, McLeod, and Guikema 2016; Li et al. 2018) these include:

- rain - air temperature (minimum, maximum and mean) - ground temperature (minimum, maximum and mean) - growing degree days - sunshine hours

The above parameters will be evaluated for the growing areas where PremA96 is currently commercially harvested. Comparison with previous seasons is useful in understanding the trends and potential cause and effects with respect to yield and fruit quality.

### 3.3 Rainfall

the 2022/2023 growing season saw high precipitation even compared to 2021/2022. The extent of rainfall can be measured in two ways: total cumulative and number of days with significant rain (arbitrarily defined as 25mm). Table 3.1 and Figure 3.2 displays the daily evolution and total rainfall for each sector and Figure 3.3 the number of days where the rainfall is greater than 25mm respectively. The analysis covers the growing season defined as the period from 1<sup>st</sup> September through 1<sup>st</sup> May.

As can be seen from @Figure 3.2 and Table 3.1 The total rainfall over the growing season was consistently greater than

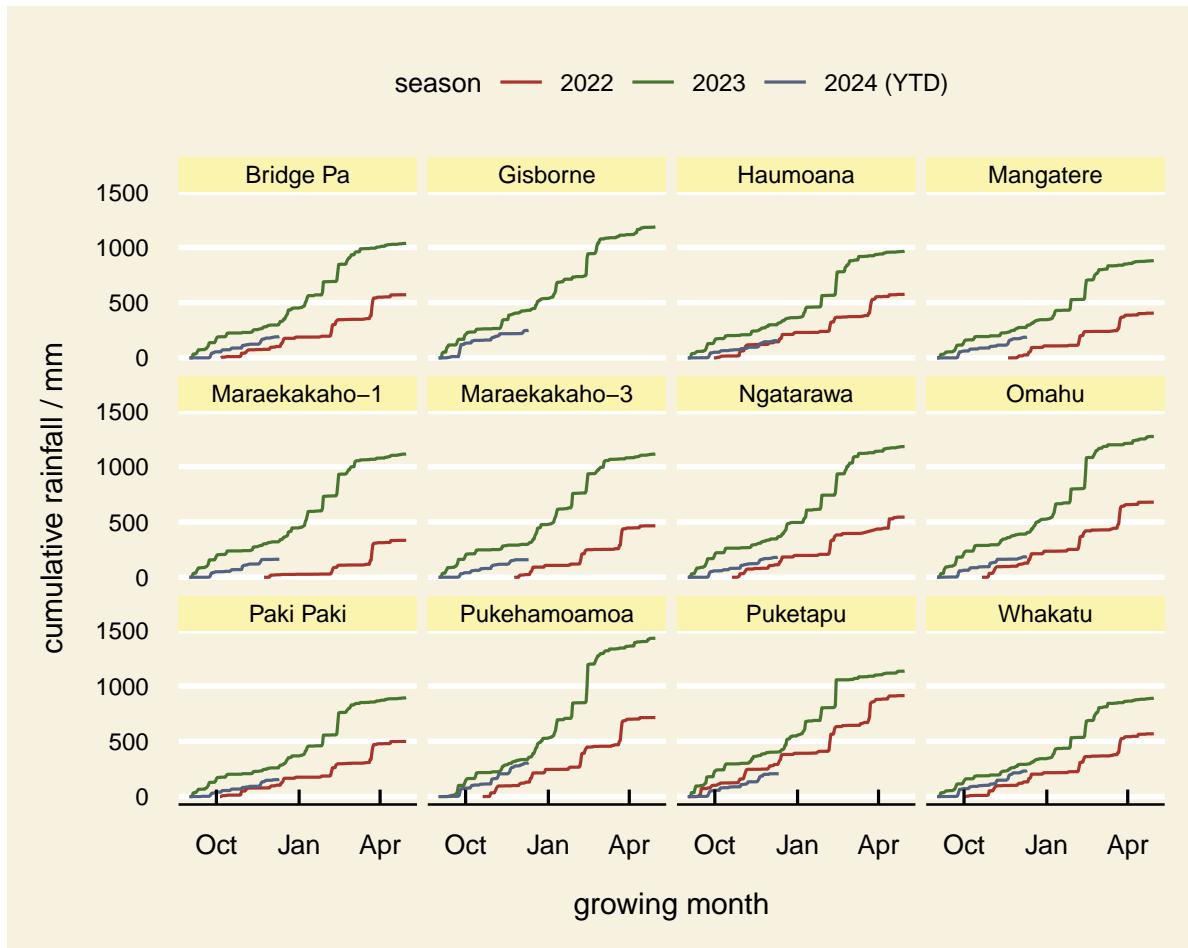


Figure 3.2: Annual rainfall for the growing season (1-September through 1-May) on Rockit™ apple orchard based weather stations. The rainfall is plotted as cumulative daily rain

Table 3.1: Annual rainfall for the growing season (1-September through 1-May) Rockit<sup>TM</sup> apple orchard based weather stations

season	annual rainfall / mm			
	2022	2023	2024	YTD <sup>1</sup>
Bridge Pa	571.2	1036.0	193.8	
Gisborne <sup>2</sup>	NA	1186.0	249.0	
Haumoana	575.0	965.6	158.4	
Mangatere	405.2	880.6	189.0	
Maraekakaho-1	333.8	1115.0	162.2	
Maraekakaho-3	465.0	1114.2	158.2	
Ngatarawa	544.0	1182.0	181.8	
Omahu	679.0	1273.2	187.2	
Paki Paki	499.0	895.2	155.0	
Pukehamoamoia	715.0	1432.2	306.8	
Puketapu	913.4	1135.7	206.6	
Whakatu	568.8	890.4	236.8	

<sup>1</sup> the last reading were taken on 13th December 2023

<sup>2</sup> the weather station in Gisborne was only established in 2023

### 3.4 Growing degree days

A common measure of heat accumulation in agriculture (and particularly horticulture) is growing degree days (GDD).

Plants generate biomass through photosynthesis. Photosynthetic activity depends to a large extent on sunlight which is typically measured in terms of radiative exposure through sunshine hours. Temperature is another important factor as it triggers and sustains changes in the apple through phyto-hormone regulation (Karami and Asadi 2017). While all stages are important to the development of the fruit the first 42 days after full-bloom (DAFB) appears to be a particularly important measure (Beaudry, Schwallir, and Lennington 1993; Bergh 1990). Temperature over this period is a major predictor final fruit size and yield (Bergh 1990). Productive heat, in horticulture, is measured through growing degree days. This is a simple measure, which subtracts a base temperature (in Rockit<sup>TM</sup> apple's case 10°C) from the average daily temperature, the difference being the number of GDD accumulated in that day. Generally the daily GDDs are summed to give a cumulative GDD over a period (The convention is to begin the accumulation at June 1st

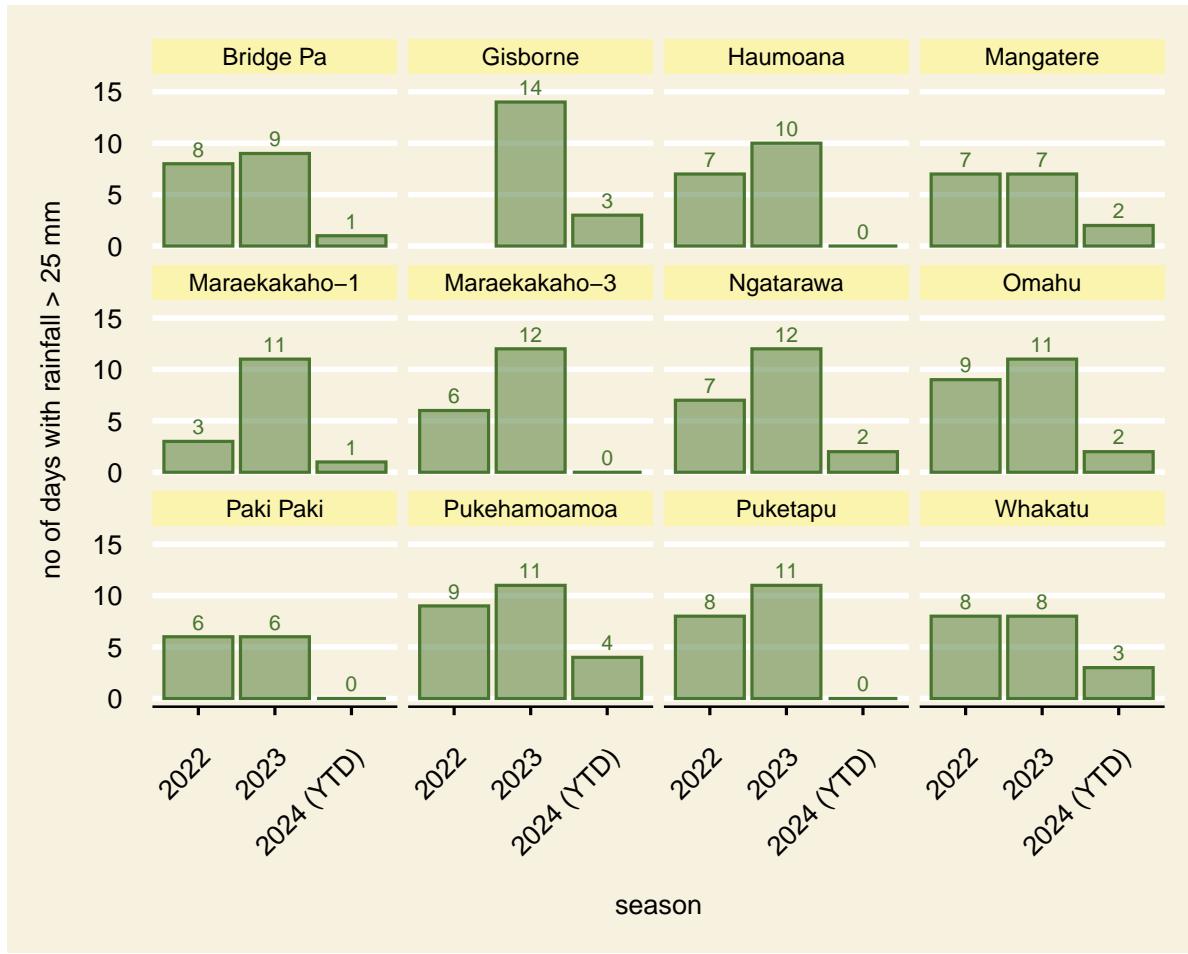


Figure 3.3: Number of days with rainfall greater than 25mm 2022, 2023 and 2024 (YTD).  
Data taken from weather station on Rockit™ apple orchards

through to May 30<sup>th</sup> the following year). The mathematical calculation of GDD is given in Appendix 16.1.

As can be seen in Figure 3.4 the accumulation of GDD over the 2022/2023 growing season was relatively consistent across the Hawke's Bay and Gisborne with annual totals given in Table 3.2. Annual totals range from 1,621°C at the Maraekakaho sector to 1,904°C at Puketapu. The 2023/2024 YTD accumulated GDDs are tracking a very similar trajectory to 2022/2023 with the exception of Gisborne which is tracking slightly lower.

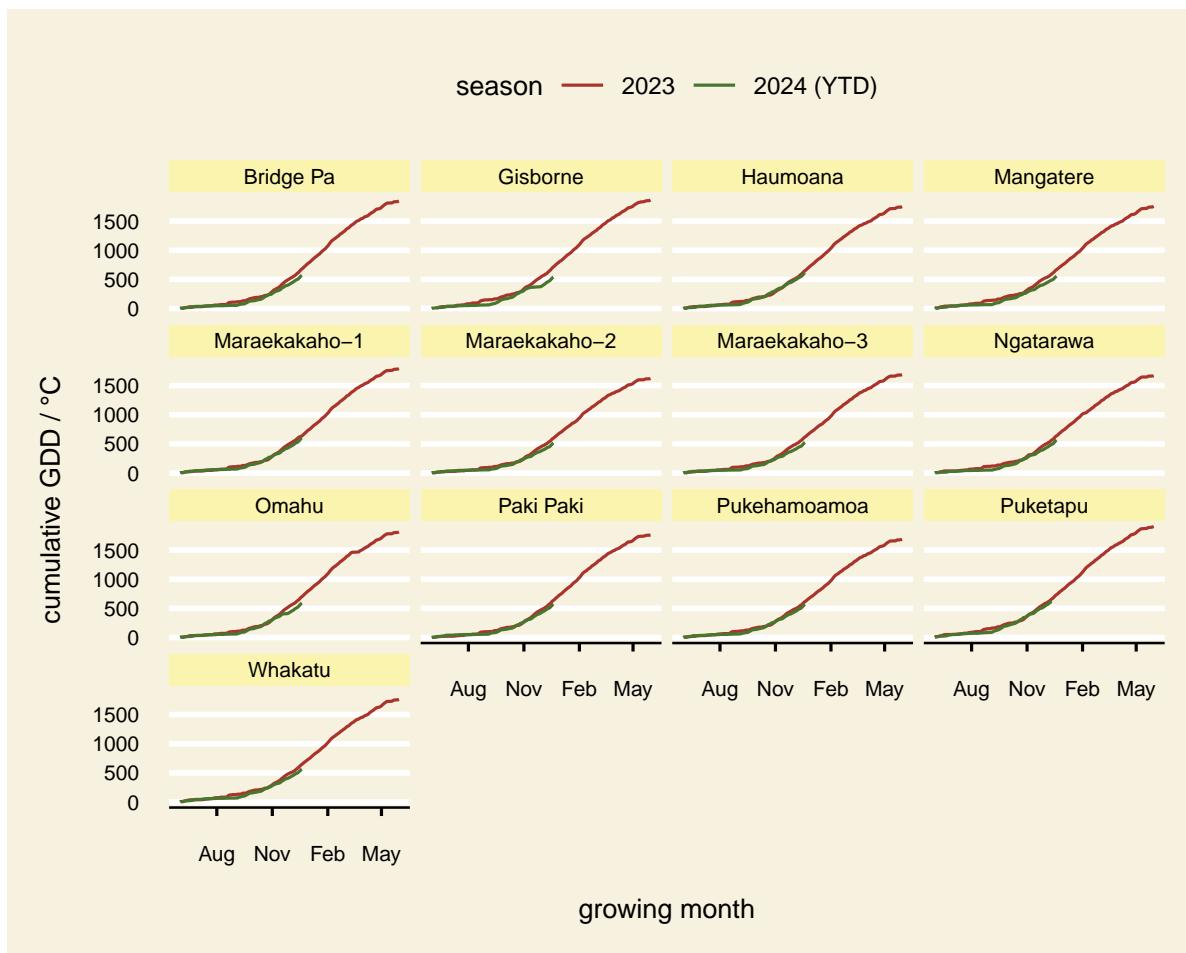


Figure 3.4: GDD for 2022/2023 and 2024 YTD growing season

Table 3.2: Regional distribution of annual GDD across Rockit™ apple growing sites

sector	annual GDD / °C	
	2023	2024 (YTD) <sup>1</sup>
Bridge Pa	1,843.8	569.1
Gisborne	1,861.0	538.7
Haumoana	1,750.0	614.4
Mangatere	1,753.4	555.0
Maraekakaho-1	1,790.1	602.4
Maraekakaho-2	1,621.2	514.4
Maraekakaho-3	1,686.9	524.0
Ngatarawa	1,670.4	564.8
Omahu	1,809.4	591.1
Paki Paki	1,761.4	573.6
Pukehamoamoa	1,684.3	567.9
Puketapu	1,904.3	618.1
Whakatu	1,763.0	563.7
<b>mean GGDs</b>	<b>1,761.5</b>	<b>569.0</b>

<sup>1</sup> the last reading were taken on 13th December 2023

Table 3.3: mean annual increase in GDD for Hawkes Bay and Gisborne regions

region	growth rate °C/year	95% confidence interval	
		lower °C/year	upper °C/year
Hawke's Bay	4.1	2.8	5.3
Gisborne	5.1	3.9	6.3

The long term trend is increasing GDD for both the Hawke's Bay and Gisborne regions. Figure 3.5 shows the annual GDD values for Gisborne and Hawke's Bay from 1940 through 2022 (Stats NZ 2023). Linear trend lines are modeled and overlaid which give an estimate of the mean growth in GDD per year since 1940. The growth rates and associated confidence intervals are presented in Table 3.3. The Hawke's Bay and Gisborne's long term trend mean growth rates are 4.1°C/year and 5.1°C/year respectively. As can be see from the spread of the historical data, however, there is considerable year-to-year variability. the mean annual GDDs for the last 10 years (2012 through 2022) are 1,908°C and 1,865.4°C for Hawke's

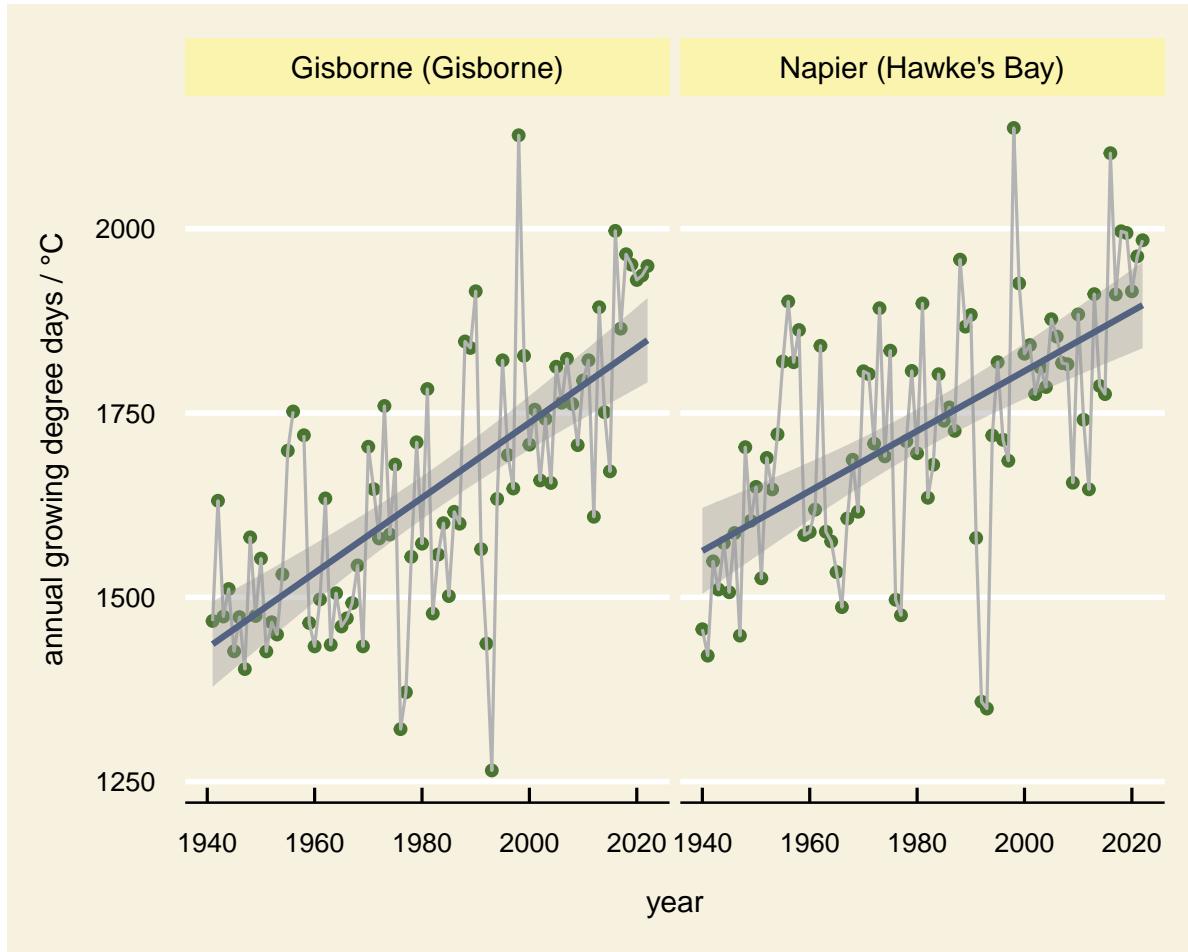


Figure 3.5: Historical annual GDD for Gisborne and Hawkes Bay from 1940 to 2022

Bay and Gisborne respectively. This compares with a mean annual GDD for the two regions of 1,761.5°C for 2023 (Table 3.2) which is almost 8% lower than the 10 year average.

### 3.5 Chill units

Dormancy is a phase of the annual cycle of the apple tree that allows it to survive unfavourably cold winter conditions. Three stages of dormancy have been defined based on the source of dormancy control: paradormancy (controlled by conditions within the tree but external to the bud, such as apical dominance), endodormancy (controlled by conditions within the bud itself) and ecodormancy (controlled by environmental conditions external to the tree such as temperature) (Parkes, Derbyshire, and White 2020). Progression through these phases is dependent on seasonal temperatures, and the length and depth of bud dormancy phases for a particular cultivar can vary between seasons and locations. The minimum accumulation of winter chill needed to break bud endodormancy and enable the shift into ecodormancy is defined as the chilling requirement (CR) (Luedeling and Brown 2011). Chilling requirements for particular cultivars are poorly understood and the range for apples has been loosely defined and is given in Table 3.4 and is adapted from (Luedeling and Brown 2011). In terms of apple physiology recent studies have identified specific genes that play a direct role in the up- and down- regulation of phytohormones in the dormant bud such as: abscisic acid, gibberellic acid, ethylene, auxin and cytokinin (Kumar et al. 2017).

Table 3.4: Chill requirement range from Luedeling and Brown (2011)

safe winter chill	RCU range	
	min	max
high	2000	NA
intermediate	700	2000
low	-1000	700

Insufficient chilling over the dormant months (i.e. the chilling requirements are not met) delays the onset of flowering and subsequent irregular breaking of bud dormancy is often observed; this can eventually effect the fruit yield and quality. Monitoring chill units is, therefore, an important tool in predicting bud break and flowering and establishing the optimum management strategy through the growing season.

### 3.5.1 Winter chill models

Two winter chill model are widely used throughout the pip fruit industry: chilling hours and richardson chill units (also known as the Utah model). The chill units are accumulated from 1<sup>st</sup> June through 1<sup>st</sup> October. The individual models are formally defined in the glossary below and mathematically in Appendix 16.2. Both are presented in Figure 3.6 and figure Figure 3.7. A summary for the 2023 and 2024 seasons for each sector is given in Table 3.5.

The accumulation of chilling hours for 2023 (i.e. the winter of 2022) was, for most sectors lower than what was observed for the 2024 harvest season. The exception being two stations at Maraekakaho. The divergence between 2023 and 2024 season is most pronounced at: Mangatere, Whakatu and Haumoana (Figure 3.6). The comparison of RCU and chilling hours highlight the difference between the two models. RCU gives the ability to accumulate negative chill units (refer to Equation 16.3) when temperature get above 15.9°C. Mid august 2022 saw a particularly warm period which saw a decrease in accumulated RCUs. the second half of September 2023 (i.e. affecting the 2024 season) was also relatively warm also and a decrease in RCU was observed in several of the blocks. The effect of the later warm weather in 2023 (i.e. 2024 harvest season) was that late September is very close to the end of dormancy and hence the warm conditions aided in compressing the bloom (**reference the phenology**).

The mean difference between the 2023 and 2024 season was 73.6 (12.1%) chill hours and 57 (5.6%) RCUs; the reason for the relative difference between the two units being due to the warm months in August and September for 2023 and 2024 respectively. Based on the aforementioned guidelines (Table 3.4) the amount of chilling was at the lower end of the intermediate level of the safe winter chill.

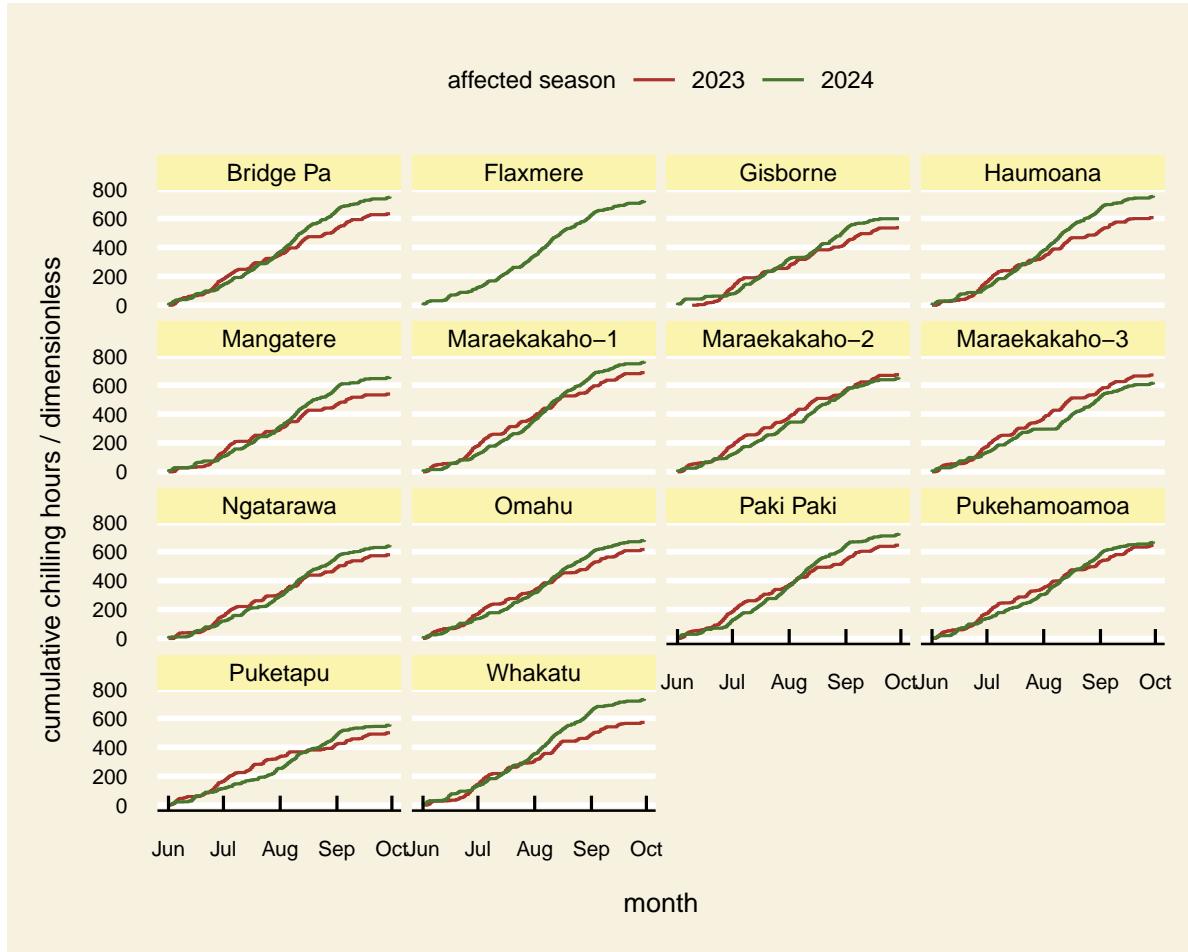


Figure 3.6: winter chill hours between the period from 1<sup>st</sup> June through 31<sup>st</sup> October

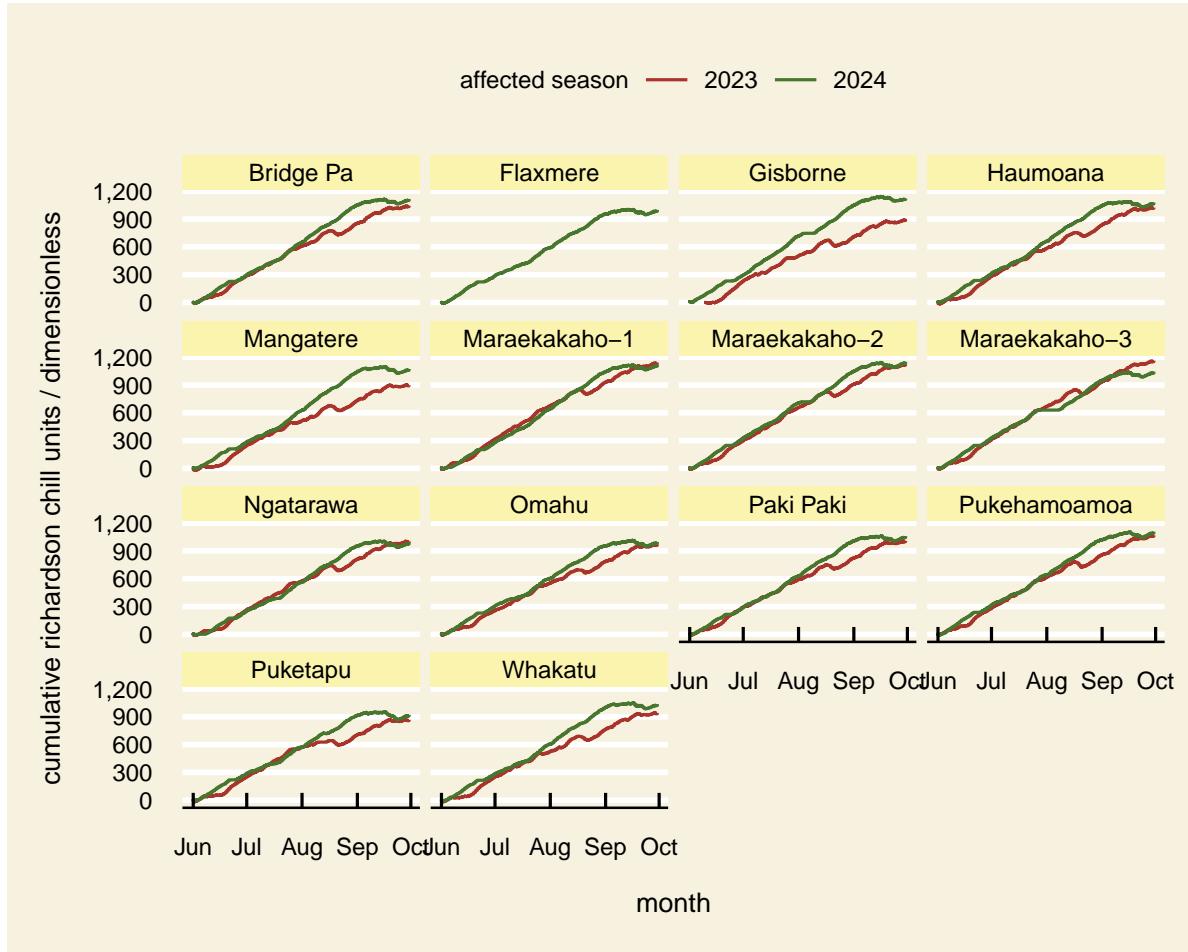


Figure 3.7: Richardson chill units between the period from 1<sup>st</sup> June through 31<sup>st</sup> October

Table 3.5: total accumulated chilling hours and RCU for the 2023 and 2024 seasons. Note the chilling period was in the year before the harvest date (i.e. the chilling for 2023 season occurred in 2022)

sector	chilling hours		RCU	
	2023	2024	2023	2024
Bridge Pa	632.0	751.0	1,043.5	1,116.0
Flaxmere	NA	722.0	NA	1,004.5
Gisborne	537.0	598.0	892.5	1,144.5
Haumoana	606.0	757.0	1,023.0	1,090.0
Mangatere	538.0	656.0	900.5	1,099.0
Maraekakaho-1	686.0	763.0	1,141.0	1,119.5
Maraekakaho-2	672.0	653.0	1,123.0	1,151.0
Maraekakaho-3	670.0	619.0	1,161.5	1,044.0
Ngatarawa	579.0	645.0	1,005.5	1,006.0
Omahu	615.0	680.0	971.0	1,015.5
Paki Paki	645.0	727.0	1,007.0	1,060.0
Pukehamoamoia	643.0	670.0	1,068.5	1,107.5
Puketapu	500.0	557.0	874.0	956.0
Whakatu	572.0	734.0	942.0	1,049.0
<b>mean</b>	<b>607.3</b>	<b>680.9</b>	<b>1,011.8</b>	<b>1,068.8</b>

## 3.6 Frost days in 2023

Frost is a significant risk in the Hawke's Bay region and

## 3.7 Glossary

**DAFB** days after full bloom - The number of days after the “full bloom” phenological stage of apple development

**GDD** growing degree days - GDD are the total number of degrees Celsius above a base threshold temperature for each day. The base threshold used is 10°C. GDD are calculated on a daily basis and typically reported on an annual cumulative measure (referred to as annual GDDs). GDD are defined mathematically in Appendix 16.1

**Chilling hours model** The Chilling Hours Model is the oldest method to quantify winter chill (Chandler, 1942). According to this model, temperatures between 0°C and

$7.2^{\circ}\text{C}$  are assumed to have a chilling effect, with each hour at temperatures between these thresholds contributing one chilling hour. Chilling hours are thus accumulated throughout the dormant season and then summed up. Chilling hours are defined mathematically in Appendix 16.2.

- RCU** Richardson chill units - also known as the “Utah model”. It contains a weight function assigning different chilling efficiencies to different temperature ranges, including negative contributions by high temperatures. This model of chill units (CU) defines a CU as the permanence of the buds for a period of 1 hour in a temperature range considered optimum ( $2.5\text{-}12.5^{\circ}\text{C}$ ) to accumulate chill. The Utah model is more complex because it introduces the concept of relative chilling effectiveness and negative chilling accumulation (or chilling negation). According to Richardson et al. (1974) temperatures between  $0$  and  $16^{\circ}\text{C}$  promote the breaking of rest, whereas temperatures  $> 16^{\circ}\text{C}$  negate such effects. Maximum promotion occurs at  $7^{\circ}\text{C}$  ( $1\text{ h at }7^{\circ}\text{C} = 1\text{ chill unit}$ ); higher and lower temperatures within the  $0\text{-}16^{\circ}\text{C}$  range are less effective. RCU are defined mathematically in Appendix 16.2

## **4 Prem A96 seasonal phenology**

# **5 pest and disease monitoring (pre-season)**

Author: Svetlana Drinnan - Fruition Technical Services Manager

## **5.1 Introduction**

This report aims to look at presence of major market access pests and diseases (P&D) in RMS orchards in Season 2022-23 by sector as well as trends in the last five years.

This analysis may assist in: - understanding differences between management areas - tracking blocks season to season - reviewing controls and understanding how effective they have been - planning P&D management for future growing seasons.

This report will cover spring/summer field assessments, trapping and harvest assessments with the focus on the following P&D's: Black Spot (BS), Codling Moth (CM), Light Brown Apple Moth (LBAM), Apple Leaf Curling Midge (ALCM), Woolly Apple Aphid (WAA) and Mealybug (MB).

## **5.2 Season 2022-2023 pest and disease summary**

### **5.2.1 Black spot**

BS control in 2022-23 has been a challenge because of persistent rain throughout the season. BS incidence across all blocks has almost doubled in 2023 harvest assessments compared to the previous season but this result needs to be seen in context of extremely high disease pressure. The establishment of early season infection was a problem at some orchards.

A number of suggestions for improved control are made including 1) maintaining a tighter protectant cover programme over ascospore release, 2) using the Integrated Disease Model to assist in identifying high risk infection periods, 3) considering combination of protectants to cover resistance risk and 4) hygiene measures during wintertime.

### **5.2.2 Codling Moth**

Almost no actionable thresholds throughout the trapping season and nil CM damage on fruit during the harvest confirms the company's very successful CM management approach which results in maintained low CM pressure status for all managing areas.

### **5.2.3 Light Brown Apple Moth**

This season recorded the lowest level of old LBAM damage (4.4%) on fruit at harvest, in the last 5 years. However, slight increase in fresh damage and live larvae, 1.5% and 2.9% respectively, is not something to ignore. An insecticide application 3-5 weeks before harvest may be considered to eliminate the risk of larval presence in fruit at harvest.

### **5.2.4 Apple Leaf Curling Midge**

ALCM appear to be well controlled across the company in Season 2022-23 with nil interception during harvest assessments in the last 4 consecutive years, all while expanding in producing hectares with many new plantings.

### **5.2.5 Woolly Apple Aphid**

For the first time in the last 5 years pre-harvest monitoring recorded WAA colonies on Rockit orchards. However, biocontrol of WAA appears to be assertive, as no unparasitized WAA was found at harvest. The incidence of A. Mali has also dropped across all blocks by 28%, but increased by 0.1% within affected blocks. It is important to remember that parasitised WAA is also considered a quarantine pest in sensitive markets.

### **5.2.6 Mealy bug & scale**

Both presence and incidence of mealy bug increased in 2023 harvest, by 6% and 0.1% respectively. Combined 0.5% of San Jose scale was also observed across all bin assessments. Both mealy bug and scale have the potential for rapid spread in the absence of appropriate control measures.

### **5.2.7 Mites**

Fruition observed pest mites on quite a few Prem A96 orchards during spring/summer monitoring this season. Although, there were a couple of blow-outs of European Red mite, they did not translate into infestation of this pest on fruit at harvest. A combination of a good pest management and effective bio-control can take credit for it.

### **5.2.8 Other Pests**

This season Rockit orchards have seen a decrease in % incidence of 'non-critical' pests like Bronze Beetle, Fullers and Noctuid damage. This is a pleasing reversal of the trend over the previous seasons where these pests were on the increase.

## **5.3 Season 2022-23 Sectors Summary**

### **5.3.1 Napier Sector**

- There was an increased incidence of Blackspot this season with most blocks in the sector showing the combined highest percentage, 7.6%, found at harvest. Blackspot was sighted at newly planted blocks during Nov-Dec monitoring, predominantly around the edges of the blocks. This may point to boundary coverage of helicopter applied sprays. Reviewing the impact of 'on the ground' issues such as equipment, spray application timing, methods may help determine the cause.
- Codling moth control has been effective this season with no incidence during harvest assessments and no actionable CM thresholds. It was a slightly different picture with LBAM though. Despite low average trap catches per week, Napier sector was the only sector that recorded all types of LBAM damage during harvest assessments including a live larva at Lawn F. However, the combined percentage was still very low at 0.3%.
- ALCM does not appear to be a critical pest for Napier sector this season. Percentage of damaged shoots increased from G2 to G3 monitoring by 20%, but no ALCM pupae was found at harvest.
- There has been some detection across most of analysed P&D this season, but it is worth mentioning that Mealybug incidence was the highest at Napier sector at 2.2%. This % does not include sooty mould which is indicative of internal mealy bug.

### **5.3.2 Havelock North Sector**

- Black spot was sighted at only one orchard during spring monitoring. This, unfortunately, resulted into 0.5% incidence during the harvest, which is a minimum pest limit for China.
- Codling Moth and LBAM controls have been effective this season with no CM thresholds throughout the entire season or CM interceptions at harvest. Only one orchard exhibited LBAM pressure this season. One Block in particular had a several blowouts in Feb-March.
- Spring/summer ALCM scouting recorded 8.1% of damaged shoots post G2, and that number jumped to 34.8% post-G3, which is the highest increase across the company. Movento applications review is recommended.
- Unparasitised WAA colonies were detected for the first time this season. As a result, the affected blocks fell into high and medium export risk for WAA sensitive markets.
- Combined ranking for sensitive market access, which includes risk factors from all assessed P&D's, placed one orchard into a high-risk level; the rest of the blocks fell into medium risk.

### **5.3.3 Bridge Pa Sector**

- Season 2022-23 has been a good season for the Bridge Pa sector with relatively low P&D pressure. Longlands orchard was the only site with actionable CM and LBAM thresholds this season.
- Similarly to Havelock Nth sector, WAA colonies were detected during field monitoring. Both affected blocks also saw a small percentage of A.Mali in their bins; the fruit was considered a high-risk line for sensitive markets based on all combined risk factors.

### **5.3.4 Puketapu Sector**

- Black spot control was very effective in Puketapu orchards this season with no detection both during the season walks and at harvest.
- Puketapu sector continues to show low pressure for CM and LBAM, recording lowest average weekly moth catch per trap, and no actionable thresholds as well as nil moths' damage interception at harvest.
- Even though Puketapu sector saw more damaged shoots with ALCM, namely 15.1% post-G2 and 27.9% post-G3, compared to last season, it was the sector with the highest % of low-risk blocks for ALCM sensitive markets.

- Puketapu sector recorded the highest interception of parasitised WAA during harvest assessments at 2.1%. Unparasitised colonies of WAA during field assessments were also recorded.

### **5.3.5 Omahu Sector**

- Black spot has been an issue this season. The disease was detected late season only with a high 10.5% and 1.2% at two adjacent blocks. Unavoidably, BS showed up at harvest assessments too. Spray programme review during the critical period (the beginning of bud growth until small fruitlet stage) is recommended.
- Omahu sector saw a reasonable LBAM pressure this season with the highest average trap catch per week, several actionable thresholds and a live larva at 9B in bin assessment.
- The sector recorded the highest percentage of ALCM damaged shoots (new infestation and old damage) both post G2 and G3, 18% and 36% respectively. Midge infestation at two blocks were high enough in combination with vigour to place these blocks into high-risk post G3.
- WAA control was very effective – it was the only sector that was completely clean of any type of WAA.

### **5.3.6 Valley Sector**

- Valley Rd sector is a new Rockit sector this season with only one year of obtained P&D data.
- Sector has showed a very good Blackspot and CM management. However, there have been some LBAM pressure with 2nd highest average trap catches per week, several thresholds and one fresh interception at harvest.
- The sector also recorded some detection of WAA during field monitoring, and combined 1.4% of A.Mali during bin assessments, however, it was below allowed maximum pest limit and did not entail any export risk.
- Bin assessments at Valley Rd and Pioneer also saw small % of other critical and non-critical P&D.

## **5.4 Black spot**

Black spot (BS) is a quarantine disease for Chinese market with Maximum Pest Limit (MPL) 0.5%.

It has been a very wet spring and summer in Hawke's Bay with moderate to heavy rains every month which has created a lot of disease pressure this season. Black spot infection

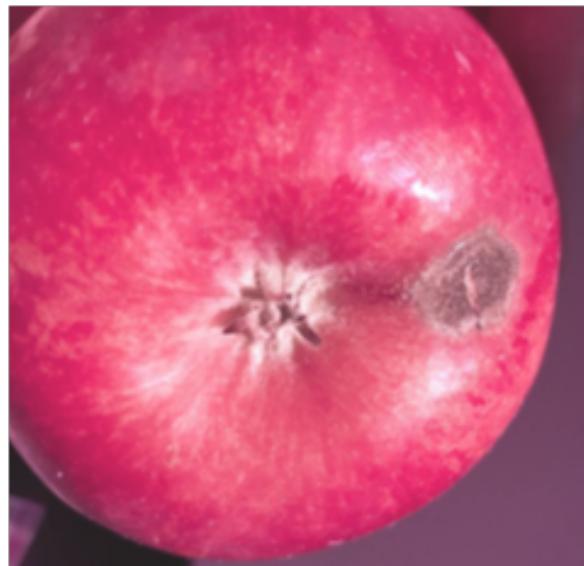


Figure 5.1: example of an apple with a black spot lesion

period risk graph below shows a number of high-risk events that occurred over the period of ascospore release (Sept-Nov) (Figure 5.2). Early spring infection period is determined by the number of ascospore available when it rains. Risk continues while wetness continues and accumulates each hour as more ascospores are released. It is critical to control this primary inoculum to minimise secondary infections as the magnitude of risk is many times greater over the primary spore release period until ascospore reaches its maturity (usually early November).

Overall, black spot control in 2022-23 appears to have been a challenge. The establishment of early season infection was a problem in blocks at the following sectors shown in Table 5.1.

Table 5.1: blocks with sighted black spot during November - December monitoring

sector	average leaves per shoot	black spot					risk level
		leaves	fruit tops (250)	fruit bottoms (750)	overall (%)		
Puketapu	11.0	0.00%	NA	0.10%	0.10%	Medium	
Havelock	12.0	0.00%	0.40%	NA	0.10%	Medium	
Twyford	15.1	0.70%	1.20%	2.80%	2.40%	High	
Twyford	13.7	0.00%	2.80%	1.20%	1.60%	High	
Whakatu	12.9	0.00%	0.80%	NA	0.20%	Medium	

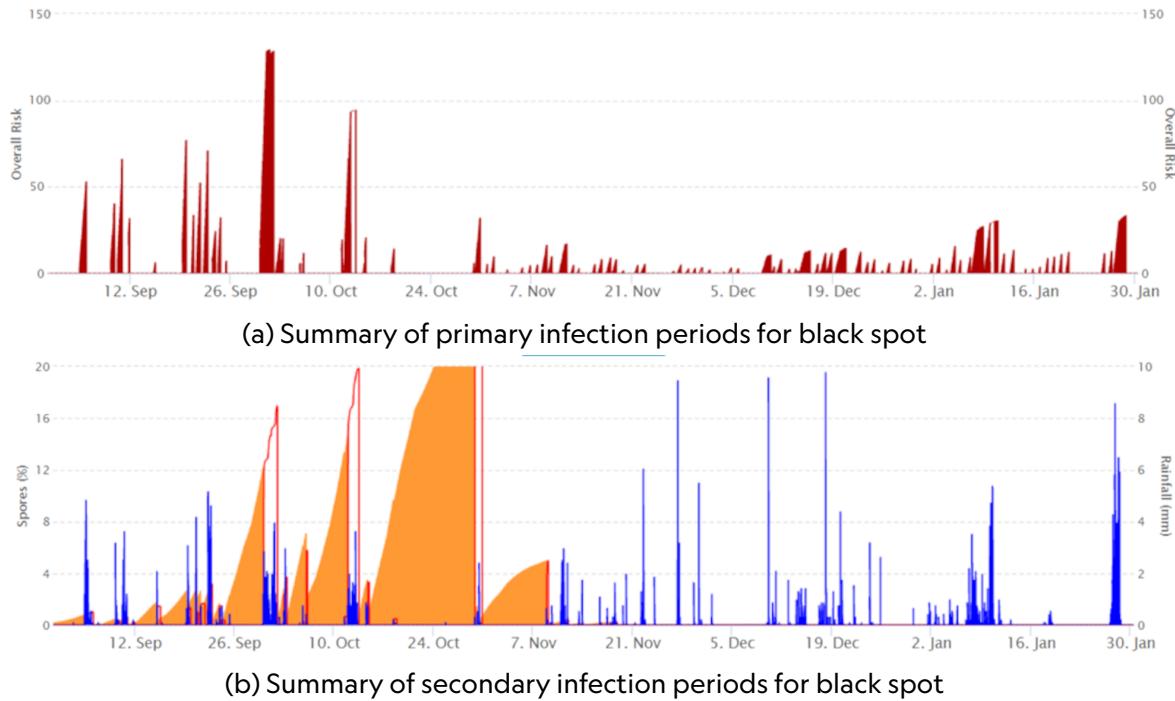


Figure 5.2: Black spot infection summary for 2022-2023 spring and summer in Hawke's Bay

The following blocks are a good example of how a secondary infection can occur during the right conditions later in the season. Even though black spot was not observed there during spring assessments (primary infections may be very few in number and therefore escape detection), these blocks were reassessed in February on manager's request, the resulting observations (Table 5.2) show quite prolific spread of black spot.

Table 5.2: two blocks with observed secondary black spot infection during February monitoring. No primary infection was detected during the November and December monitoring

average leaves per shoot	black spot				overall (%)	risk level
	leaves	fruit tops (250)	fruit bottoms (750)			
11.2	2.00%	12.70%	4.00%		10.50%	High
11.6	NA	1.50%	0.40%		1.20%	High

Disease levels in November was a good indicator of incidence at harvest. Black spot

incidence across all blocks during harvest assessments increased by 11.4% compared to the last season. Black spot incidence within affected blocks jumped to 0.7%, which is a 0.4% increase from last season (Table 5.3 and Graph 3).

Table 5.3: two blocks with observed secondary black spot infection during February monitoring. No primary infection was detected during the November and December monitoring

year	monitoring		
	across all blocks	within affected blocks	spring monitoring
2019	11.10%	0.60%	0.03%
2020	14.90%	0.20%	0.00%
2021	8.80%	0.10%	0.00%
2022	1.36%	0.30%	0.00%
2023	2.50%	0.70%	0.10%

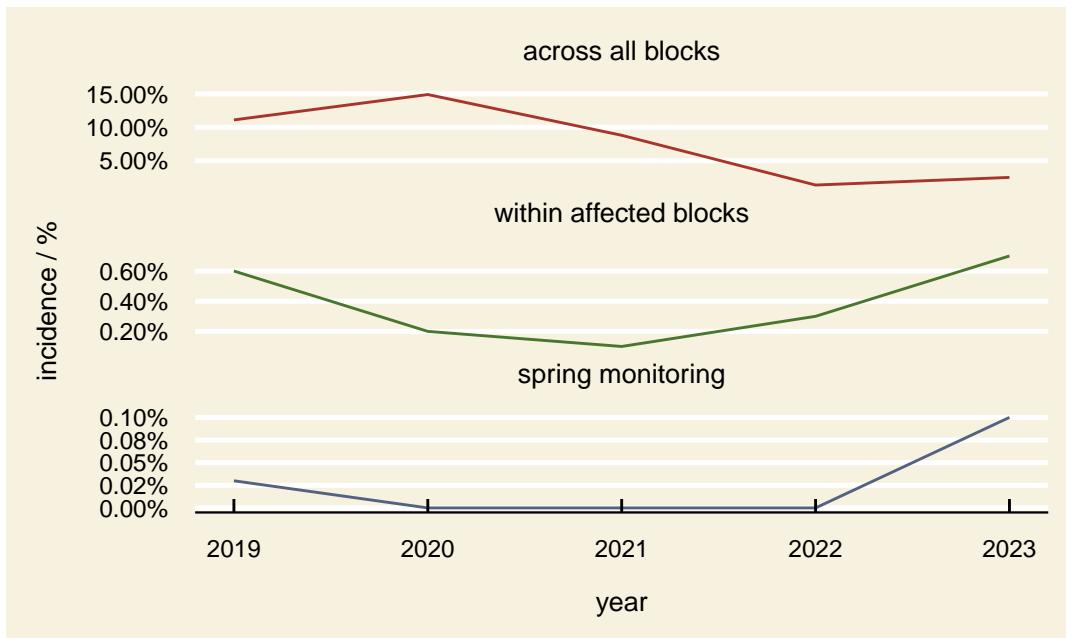


Figure 5.3: historical mean incidence of black spot across different monitoring scenarios from 2019 through 2023

The Naier sector has recorded the highest combined percentage of black spot, 7.6%, found at harvest (Table 5.4), followed by Omaha, 4.1%, and Havelock Nth, 0.5%.

Table 5.4: black spot percentage incidence detected at harvest 2023 by sector

sector	black spot
	percent
Napier	7.60%
Omahu	4.10%
Havelock North	0.50%

### 5.4.1 Conclusion/Recommendations

- Rockit's black spot incidence across all blocks has almost doubled in 2023 harvest assessments compared to the previous season, mainly due to increased numbers of bin assessments at orchards with known disease presence from spring assessments. Assessing risk factors against spray programme is recommended for these blocks to see where errors might have happened, i.e. equipment (rates and calibration), timing with respect to weather conditions (coverage and drying times), product (resistance possibilities) etc.
- Maintain a tight protectant cover programme over ascospore release. A few uncontrolled primary infections can set up an orchard for a major blackspot problem later if other favourable factors fall in place.
- Use the Integrated Disease Model which may assist in identifying high-risk infection periods especially if these events are not readily recognized.
- Regardless of amount of BS found during spring assessments, it may still be advisable to apply a BS protectant fungicide throughout the season if an extended (>48 hours) wet period is forecasted to prevent conidial risk mid- to late-season.
- Winter is the perfect time to control the disease with hygiene measures, as often this disease originates from the last season's spores. Overwintering spores are looking to infect, and more spores in the orchard means higher chance they will during the right conditions. Successful black spot management involves keeping the primary inoculum levels to a minimum.

## 5.5 Codling moth

### 5.5.1 Overview

Codling Moth (CM) is quarantine pest for Taiwan, China and Japan markets with Maximum Pest Limit (MPL) 0%.

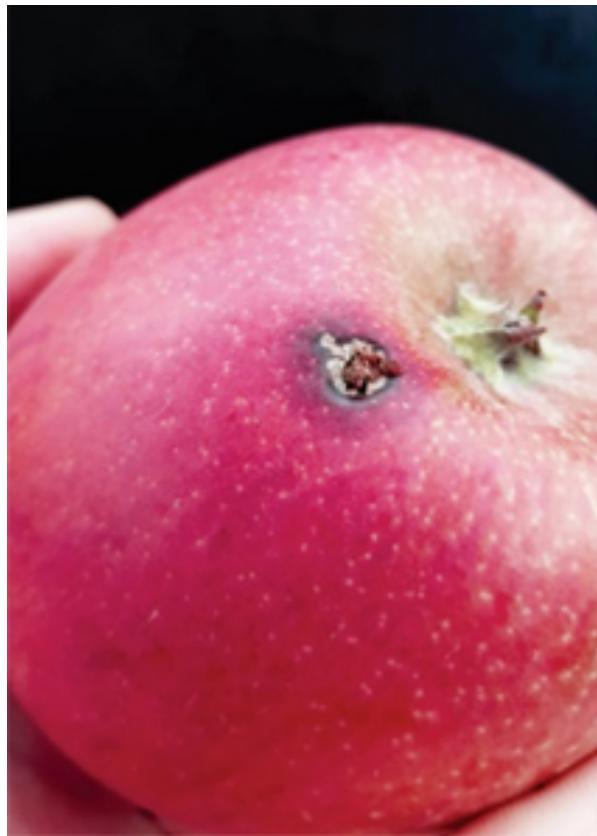


Figure 5.4: example of an apple with a black spot lesion

During harvest assessments we look for three types of codling moth damage on fruit: Old damage, New/fresh damage, and codling moth larvae. Historically, Rockit™ apple's harvest assessments have been free from any fresh codling moth damage or live larvae. This season CM control has improved even further with no codling moth damage to fruit being found at all, not even old chews or stings (Table 5.5, Figure 5.5).

Table 5.5: two blocks with observed secondary black spot infection during February monitoring. No primary infection was detected during the November and December monitoring

year	codling moth incidence	
	across blocks	within affected blocks
2019	0.00%	0.00%
2020	4.30%	0.20%
2021	29.40%	0.10%
2022	11.40%	0.10%
2023	0.00%	0.00%

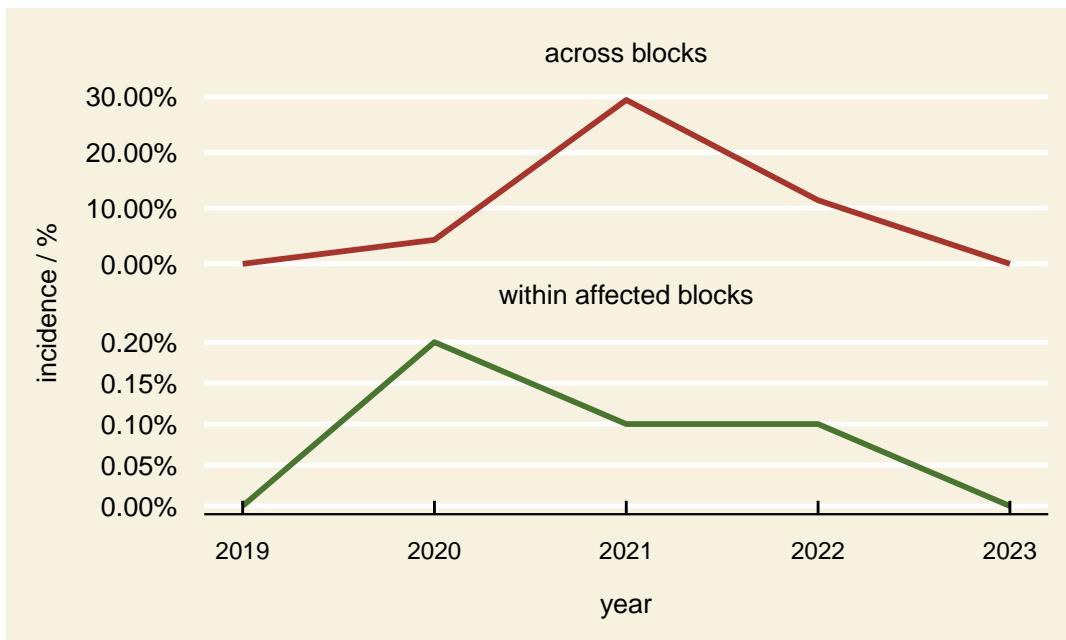


Figure 5.5: historical mean incidence of codling across different monitoring scenarios from 2019 through 2023

### 5.5.2 By Sector 2022-23

Seasonal trapping records also indicate that codling moth pressure was very low (below 0.5 moths per trap per week on average) and well controlled through spraying programme and use of mating disruption across all management areas (Figure 5.7). There was only one actionable threshold at a non-CMSM orchard throughout the entire season.

Statistical analysis of trapping data showed that Bridge Pa sector has caught more moths per week on average this season followed by Havelock North, Omaha and Valley. Puketapu and Hastings sectors had the lowest codling moth pressure this season (Figure 5.6).

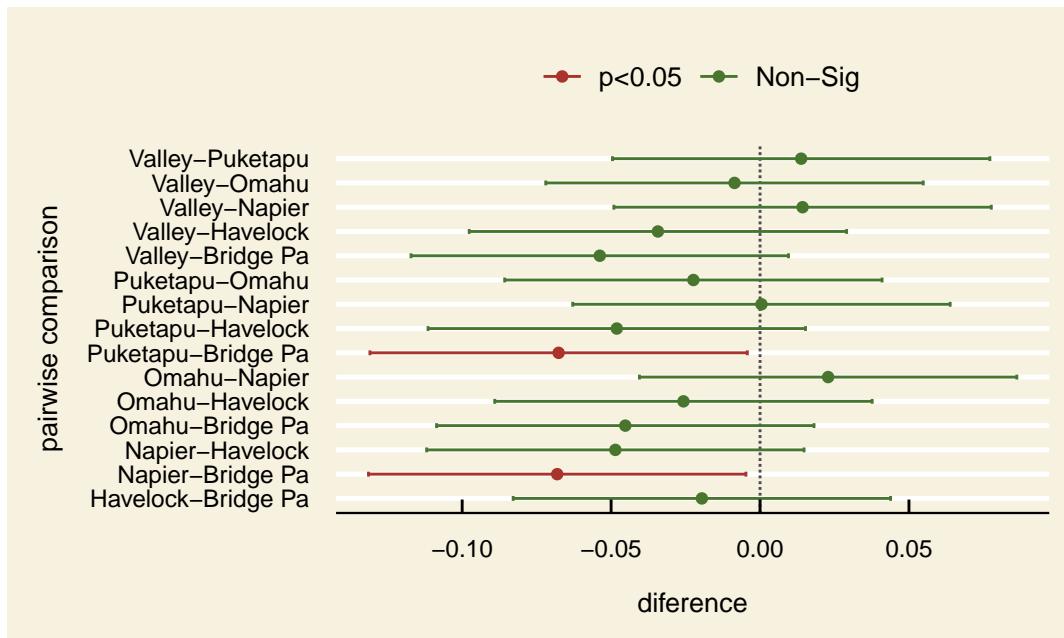


Figure 5.6: pairwise comparison of sectors using Tukey HSD post hoc test

### 5.5.3 Recommendations

Follow the same controls and spray programme next season as almost no actionable threshold throughout the trapping season and nil CM damage on fruit during the harvest confirms the company's successful CM management approach which results in maintained low CM pressure status for all managing areas.

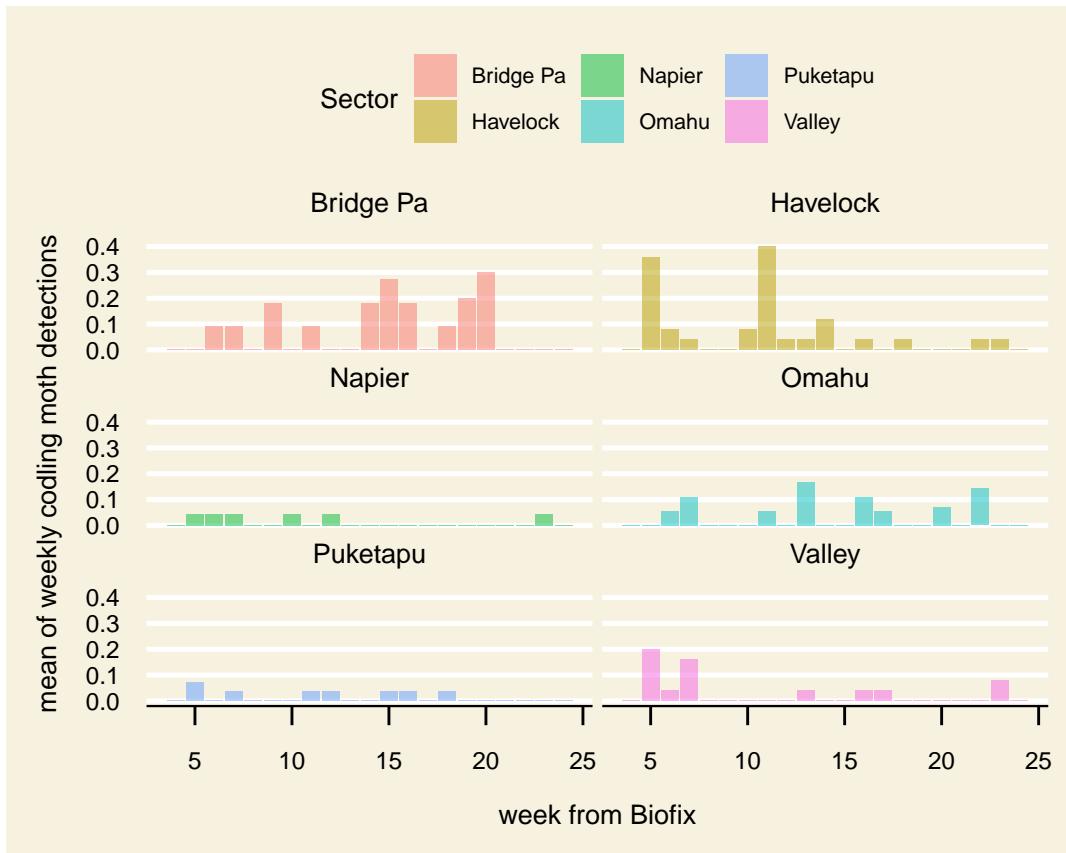


Figure 5.7: Average CM catch per trap/week in 2022-23



Figure 5.8: example of damage to fruit caused by light brown apple moth

## 5.6 Light brown apple moth

Light brown apple moth (LBAM) is a quarantine pest for some key markets: Japan, USA with maximum pest limit (MPL) 0%, and Taiwan, China with MPL 0.5%.

Same as with codling moth, during harvest assessments we look for three types of leaf roller damage on fruit: old damage, new damage, and codling moth larvae.

Season 2022-23 has seen a slight drop in old light brown apple moth damage incidence during harvest assessments both across all blocks and within affected blocks. However, there was a small increase in both fresh damage and live larvae compared to last season (Figure 5.9, Figure 5.10, Table 5.6, Table 5.7).

Light brown apple moth flying activity generally picks up again in February, around the time when Prem A96 fruit matures. So, it is highly recommended that an insecticide is applied 3-5 weeks before harvest to eliminate the risk of larval presence in fruit at harvest.

Table 5.6: Average incidence of light brown apple moth across all blocks between 2019-23

year	LBAM incidence		
	old	fresh	larvae
2019	11.10%	0.00%	0.00%
2020	25.50%	0.00%	0.00%
2021	55.90%	2.90%	2.90%
2022	11.40%	0.00%	0.00%
2023	4.40%	1.50%	2.90%

Table 5.7: Average incidence of LBAM within affected blocks between 2019-23

year	LBAM incidence		
	old	fresh	larvae
2019	0.10%	0.00%	0.00%
2020	0.60%	0.00%	0.00%
2021	0.20%	0.10%	0.10%
2022	0.20%	0.00%	0.00%
2023	0.10%	0.10%	0.10%

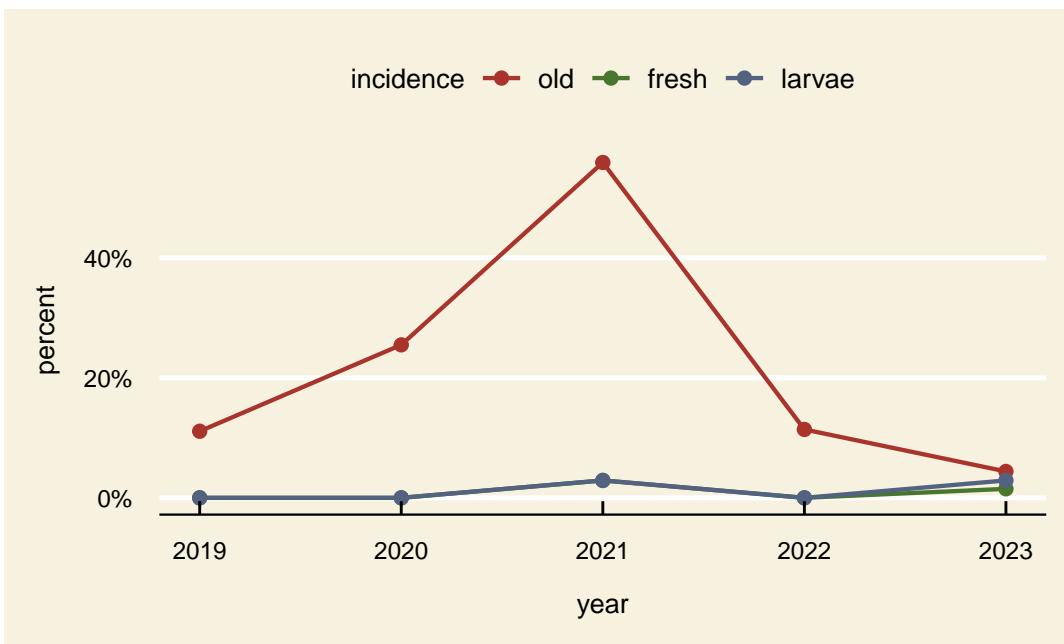


Figure 5.9: Average incidence of LBAM across all blocks between 2019-23

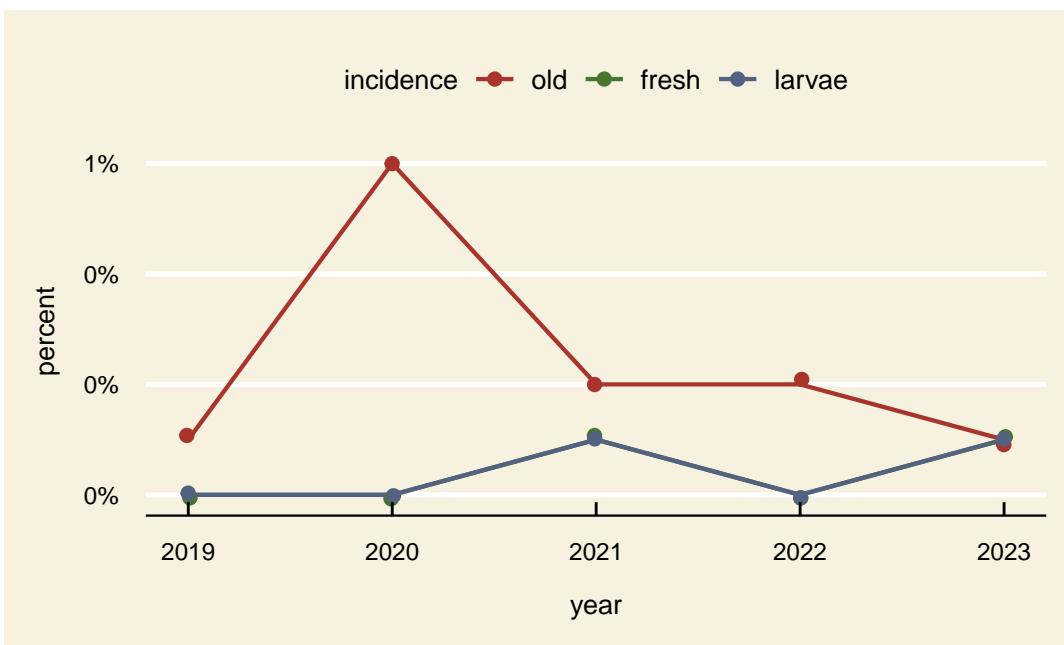


Figure 5.10: Average incidence of LBAM within affected blocks between 2019-23

### 5.6.1 By Sector 2022-23

Napier sector was the only sector that recorded all types of LBAM damage during harvest assessments, however, the combined percentage was still very low at 0.3% (Table 5.8).

Trapping data analysis placed Omaha sector at most pressure with the highest average moth catch per week (Table 5.8, Figure 5.11). Overall LBAM pressure on Rockit orchards was relatively low and mainly built up towards the end of the season with several blocks being the only management areas with actionable LBAM thresholds.

Table 5.8: Light brown apple moth percentage incidence detected at harvest 2023 by sector

sector	LBAM, incidence %		
	old	fresh	larvae
Havelock North	0.10%	0.00%	0.00%
Omahu	0.00%	0.00%	0.10%
Valley	0.00%	0.10%	0.00%
Napier	0.20%	0.00%	0.10%

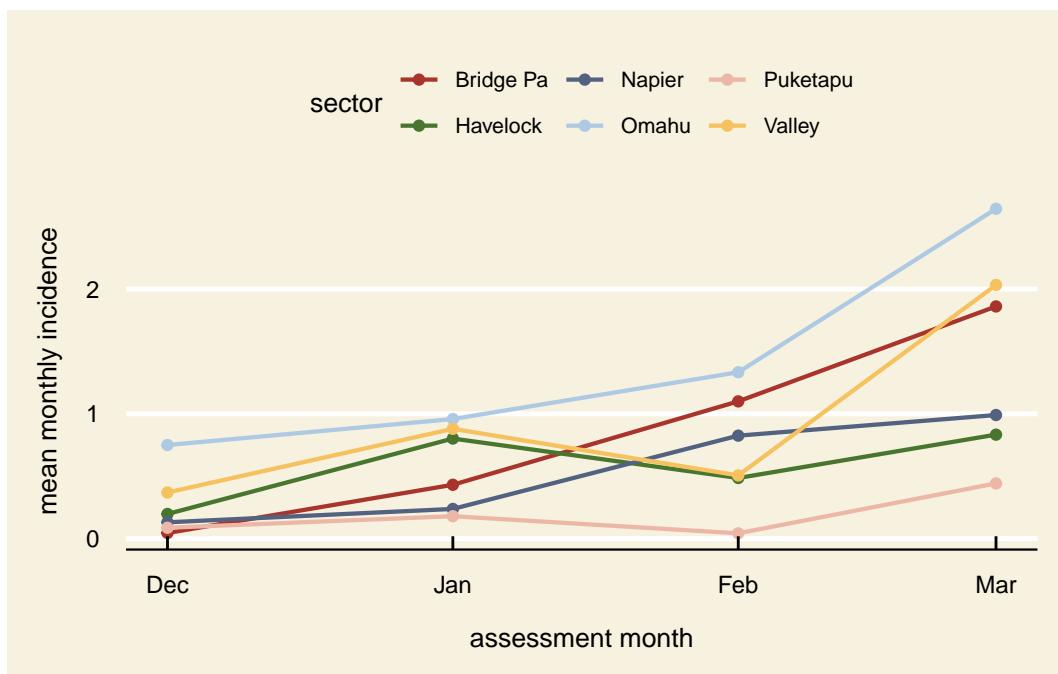


Figure 5.11: Average LBAM catch per trap/week in 2022-23

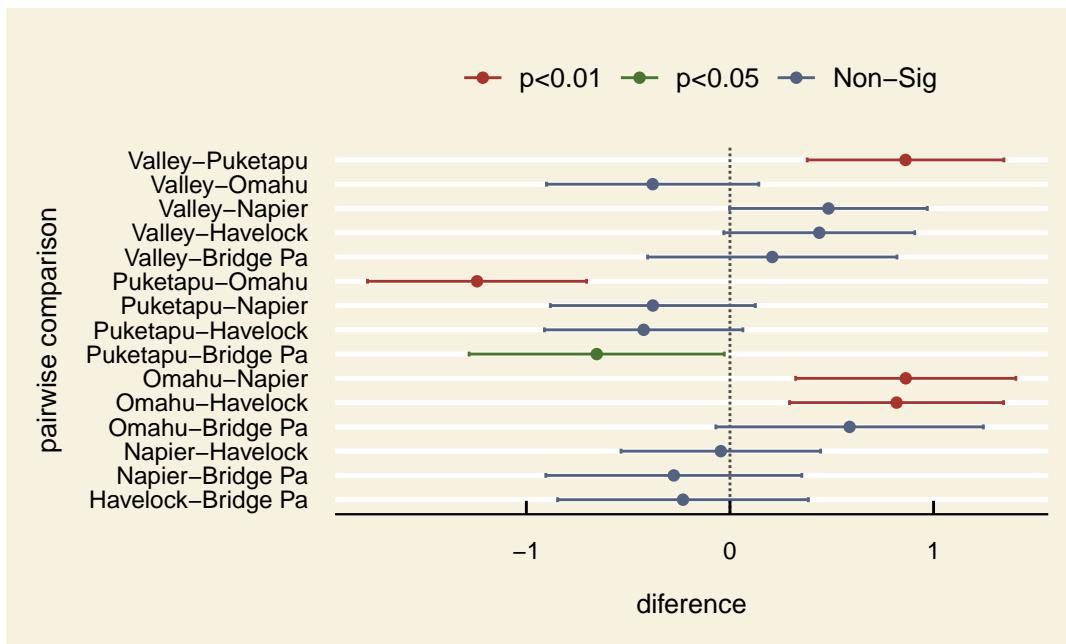


Figure 5.12: pairwise comparison of sectors using Tukey HSD post hoc test

### 5.6.2 Conclusion/recommendation

- Overall LBAM control in 2022-23 was similar to the previous season.
- Fresh damage and larval finds during harvest as well as an increase in moths catches towards the end of the season, once again confirms that LBAM are most active in autumn. A cover around mid-February on blocks with known LBAM pressure could be beneficial to keep moths' numbers and fresh damage minimal before harvest.

## 5.7 Apple leaf curling midge

Apple Leaf Curling Midge (ALCM) is quarantine pest for China, Japan with Maximum Pest Limit (MPL) 0.5%. Access to Taiwan relies on nil detected apple leaf curling midge.

ALCM is a difficult pest to control. Effective control can only be achieved when several strategies are used in combination with each other: on orchard monitoring for tree vigour and new shoots damage, Movento™ applications and fruit assessments for ALCM pupae presence. Although, traditionally monitoring for ALCM is done in summer (post 3rd midge generation, G3), knowing ALCM presence on orchards from generations 1 (G1) and 2 (G2) can assist in control strategies with focus on G3 to minimise export risk.



Figure 5.13: example of damage to fruit caused by apple leaf curling midge

On orchard monitoring post G2 and G3 returned the following average results shown in Table 5.9 :

Table 5.9: mean results for post G2 and G3 assessments for 2023 harvest season

generation	vigour <sup>12</sup>	midge damage %			overall risk
		old <sup>1</sup>	fresh <sup>1</sup>		
G2	62%	0.6%	0.7%	high	
G3	45%	0.6%	2.8%	medium	

<sup>1</sup> Average % is calculated across all assessed blocks, individual results

vary;

<sup>2</sup> actively growing shoots %

Overall risk calculations are based on tree's active growth and new midge damage. Tree growth is obviously important in young orchards and a high risk ALCM rating has to be taken in context with canopy development objectives. Quite often a block falls into a high risk due to high vigour while midge infestation stays relatively low. These results are useful as a guidance in "on the ground" decision making and in planning for lower risk lines of fruit. However, they are not a complete and final ruling on export risk for ALCM sensitive markets, finds at harvest bin assessment are.

The following data analysis shows that despite a 22% increase in infected shoots post G3 (new, old or broken leaves), ALCM presence on orchards did not translate into an export risk during harvest as there was nil % of ALCM detection in bin assessments (Table 5.10, Figure 5.14).

Table 5.10: Average incidence of ALCM between 2019-23

year	ALCM incidence %		
	across all blocks	within affected block	summer infected shoots
2019	11.0%	0.1%	12.1%
2020	0.0%	0.0%	21.1%
2021	0.0%	0.0%	7.9%
2022	0.0%	0.0%	7.3%
2023	0.0%	0.0%	29.7%

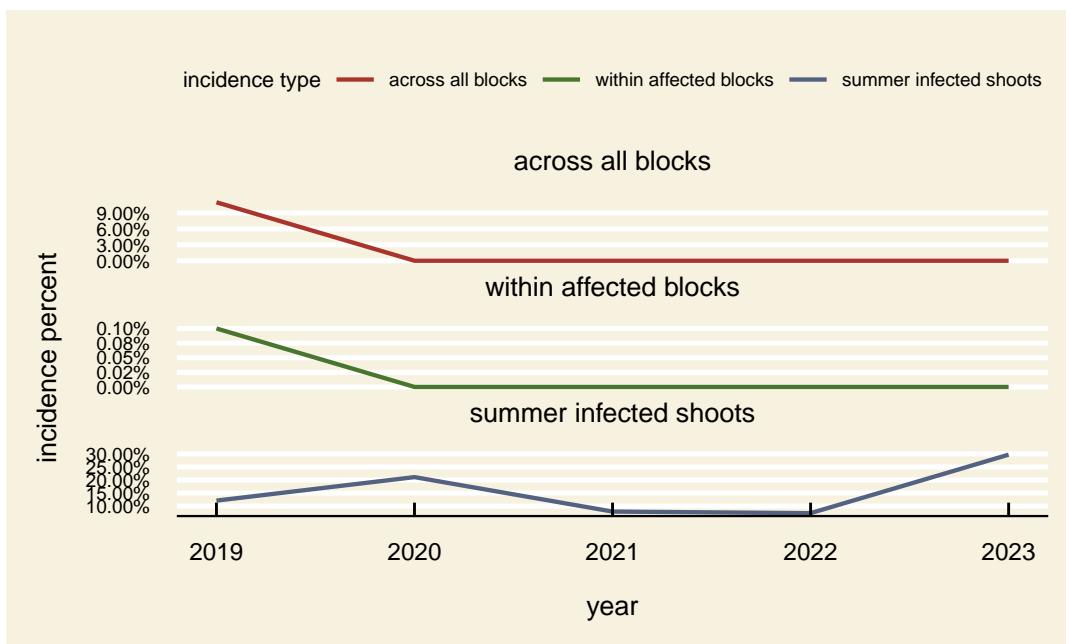


Figure 5.14: incidence of ALCM taken at harvest assessment from 2019 through 2023

### 5.7.1 By sector 2022-2023

Below charts show how number of damaged shoots increased across all sectors during post G3 assessments. Omaha sector recorded the highest percentage of damaged shoots (new infestation and old damage) both post G2 and G3, 18% and 36% respectively (Figure 5.15). It was also the only sector with midge infestation high enough to place some blocks into high-risk post G3 (Figure 5.16).

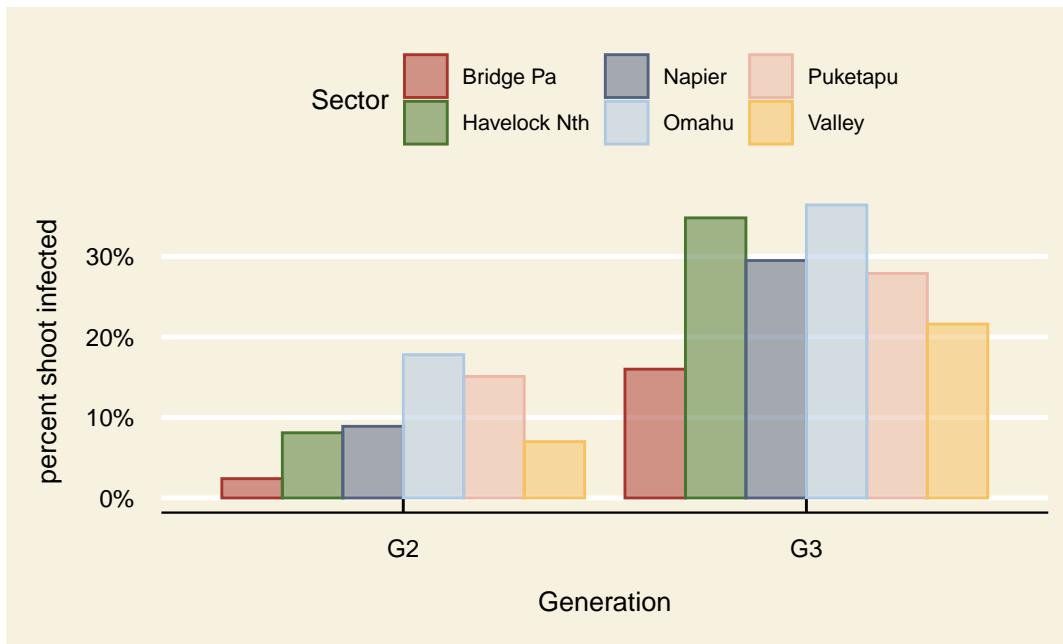


Figure 5.15: Damaged shoots post G2 and G3 by Sector for 2023 harvest

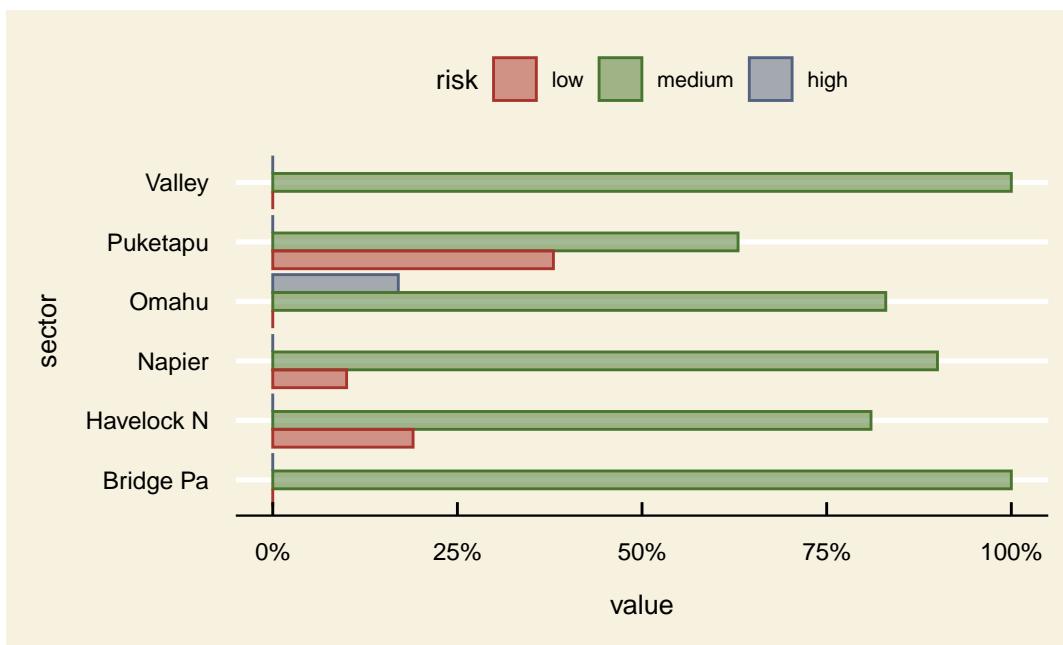


Figure 5.16: ALCM risk factor for 2023 summer shoots assessments

### **5.7.2 Conclusion / recommendations**

- ALCM appears to be well controlled across the company with nil interception during harvest assessments in the last 4 consecutive years, all while continue expanding in producing hectares with many new plantings.
- ALCM is a hard pest to tackle, and there is not a silver bullet for its control. A combination of strategies including tree vigour control, on orchard monitoring, Movento™ applications at right timing is recommended as the most efficient way for ALCM management.
- The NZAPI ALCM population regional graphs is the best available guide to go off for Movento™ applications' timing for better ALCM control.

## **5.8 Wooly apple aphid**

Woolly Apple Aphid (WAA) is quarantine pest for markets such as China and Taiwan with Maximum Pest Limit (MPL) 0.5%.



Figure 5.17: example of damage to fruit caused by wooly apple aphid

Successful control of WAA is achieved by maintaining high populations of its natural predator, parasitoid wasp *Aphelinus mali* (A.Mali). During both on orchard monitoring and harvest assessments we distinguish the two. We look for unparasitized WAA (WAA) and WAA parasitised with the wasp (A.Mali). If incidence of A.Mali prevails, this indicates effective bio-control. However, both types are recognised as quarantine pests.

For the first time in the last 5 years pre-harvest monitoring recorded WAA colonies on Rockit™ apple orchards. Below is the list of blocks that were placed in either medium or

high risk during on orchard assessments:

Table 5.11: medium and high risk blocks from the 2023 harvest season

woolly apple aphid						
date	sector	% infested shoots	live	parasitised	% parasitised	risk
27-Feb-23	Puketapu	5%	13	8	38%	Medium
23-Jan-23	Bridge Pa	12%	27	2	7%	High
31-Jan-23	Havelock	10%	153	20	12%	High
20-Feb-23	Havelock	5%	69	23	25%	Medium
31-Jan-23	Havelock	3%	22	24	52%	Medium
31-Jan-23	Valley	20%	448	940	68%	Medium

Table 5.12: Definition of WAA risk parameters

key	WAA risk				timing
	low	medium	high		
% infested shoots	<2%	2-5%	>5%	mid-season & pre-harvest	
% parasitism	>25% (effective control)		<25%	mid-season	

More than 5% shoot infestation of WAA means that a block is higher risk for fruit infestation at harvest (live WAA or parasitised), and therefore, is a higher risk in export market. Pre-harvest assessments certainly were a good indicator of what to expect at harvest. Same orchards recorded parasitised WAA during harvest assessments. Overall, the incidence of unparasitised WAA both across all blocks and within affected blocks was non-existent this season, which suggests that the parasitoid wasp caught up with the WAA population towards the end of the season despite the cooler spring/summer. The incidence of A. Mali has dropped across all blocks by 28%, but increased by 0.1% within affected blocks (Table 5.13, Figure 5.18).

Table 5.13: Average incidence of WAA and A.Mali in Rockit harvest assessment between 2019-23

year	across all blocks		within affected blocks	
	WAA	A.Mali	WAA	A.Mali
2019	11.1%	27.8%	0.1%	0.1%
2020	2.1%	8.5%	0.1%	0.3%
2021	8.8%	20.6%	0.1%	0.1%
2022	4.5%	54.5%	0.1%	0.2%
2023	0.0%	26.0%	0.0%	0.3%

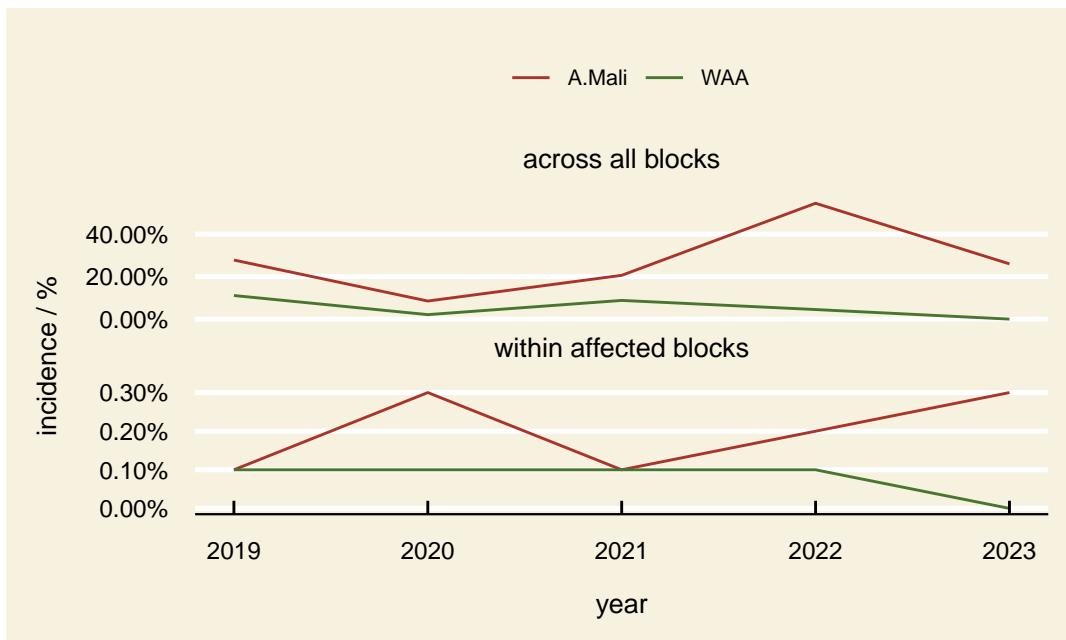


Figure 5.18: Average incidence of WAA and A.Mali in Rockit harvest assessment between 2019-23

### 5.8.1 By Sector 2022-23

Puketapu sector recorded the highest interception of parasitised WAA during harvest assessments at 2.1%, followed by Valley, Havelock Nth, Napier and Bridge PA. Omaha was the only sector that was completely clean of any type of WAA.

Table 5.14: A.Mali finds at harvest by Sector

sector	A.Mali incidence
Puketapu	2.1%
Valley	1.4%
Havelock Nth	0.7%
Napier	0.4%
Bridge Pa	0.3%

### 5.8.2 Conclusion/Recommendations

- A. Mali wasp is still the best (and free) control of WAA but emerges later than WAA crawlers and is also conditional on spring temperatures.
- Early seasons cover sprays are best as colonies are small and crawlers are more vulnerable, as well as a good way to protect the overwintering wasp.
- To archive “zero” fruit infestation, there needs to be close to zero shoot infestation from mid-January onwards.
- Continue with mid-season WAA and A.Mali population monitoring to assess the level of risk for market access at harvest. Pre-harvest monitoring for WAA infestation can either reassure or confirm the problem.
- To lower the risk of WAA, tree structure management is recommended, i.e. open canopy, removal of suckers, summer prune and thinned fruit bunches to singles or doubles.

## 5.9 Mealy bug

Mealy bug (MB) is quarantine pest for Taiwan, Thailand, Japan USA markets with Maximum Pest Limit (MPL) 0.5%, and Australia with 0% tolerance.

Season 2022-23 continued a trend of increased percentage of blocks recording MB and the severity of the incidences during harvest assessment. There were 6% increase in incidence across all blocks compared to last season, and 0.1% increase in incidences within affected blocks (Table 5.15, Figure 5.20). Below data analysis does not include sooty mould, though it is indicative of internal MB.



Figure 5.19: example of damage to fruit caused mealybug

Table 5.15: Average incidence of Mealy bug in Rockit harvest assessment between 2019-23

year	mealy bug incidence	
	across all blocks	within affected blocks
2019	38.9%	0.1%
2020	2.1%	0.1%
2021	2.9%	0.1%
2022	20.5%	0.1%
2023	26.0%	0.2%

### 5.9.1 By Sector 2022-23

Napier sector recorded the highest combined incidence of MB, 2.2% followed by Havelock Nth, 0.6%, Valley, 0.3% and Omaha at 0.1% (Table 5.16). Puketapu and Bridge Pa were two sectors with nil MB interceptions during harvest assessments.

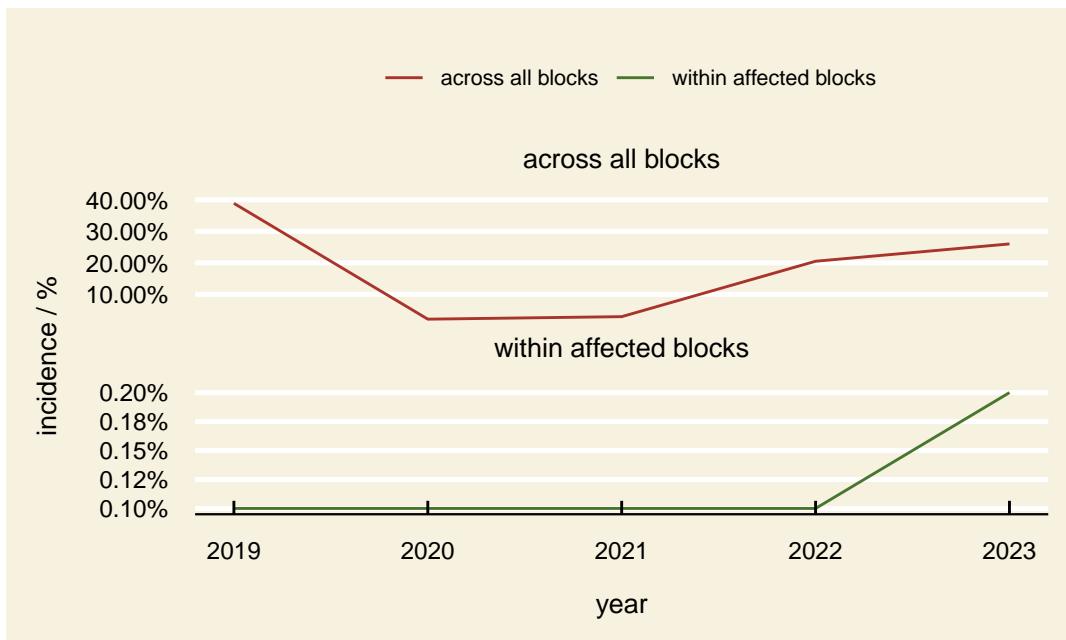


Figure 5.20: Average incidence of Mealy Bug in Rockit harvest assessment between 2019-23

Table 5.16: Mealy bug finds at harvest by Sector

sector	mealy bug incidence
Napier	2.2%
Havelock Nth	0.6%
Valley	0.3%
Omahu	0.1%

## 5.10 Scale

Scale monitoring is carried out in summer (early February) over 500 fruit per block. Pre-harvest on-fruit scale assessments on Rockit blocks did not record any pest's sighting this season. On fruit inspection can be difficult: fruit should be checked with paying special attention to the calyx at the same time as a great care is taken not to knock it off the branch.

Despite the clean pre-harvest results, the following blocks recorded non-zero levels of San Jose scale during harvest assessments:

Table 5.17: blocks (anonymised) with San Jose scale observations during the harvest assessment 2023

sector	San Jose scale
Valley	0.1%
Valley	0.1%
Havelock Nth	0.1%
Havelock Nth	0.1%
Havelock Nth	0.1%

Both Mealy bug and scales have the potential for rapid spread in the absence of appropriate control measures.

## 5.11 Mites

Mites' monitoring is recommended to carry out at least twice during a growing season: in late spring and late summer. At each assessment Fruition team checks 50 leaves per blocks for two pest mites: European red mite (ERM) and two-spotted spider mite, as well as any predator (beneficial) mites. Season 2022-23 saw quite a lot of ERM on Rockit orchards, however, only one block in the Puketapu sector reached a threshold set at 30% during spring assessment, and a block in the Omaha sector was near a threshold set at 75% during summer assessment. Many predator mites were also observed, which speaks of a good bio-control on Rockit orchards.

## 5.12 Other pests

In recent years we have noticed a worrying trend of increased incidence of several 'non-critical pests' during harvest assessments: Bronze Beetle, Fuller's Rose Weevil and Noctuid moth. Even though these pests are considered 'non-critical', their damage on fruit still causes rejects on a packing line and are worth of keeping an eye on.

It is pleasing to see that these pests' numbers have declined in 2022-23 compared to last two seasons. However, incidence of Fullers' and Noctuid's presence on Rockit orchards has not yet reached lower levels observed in 2020.

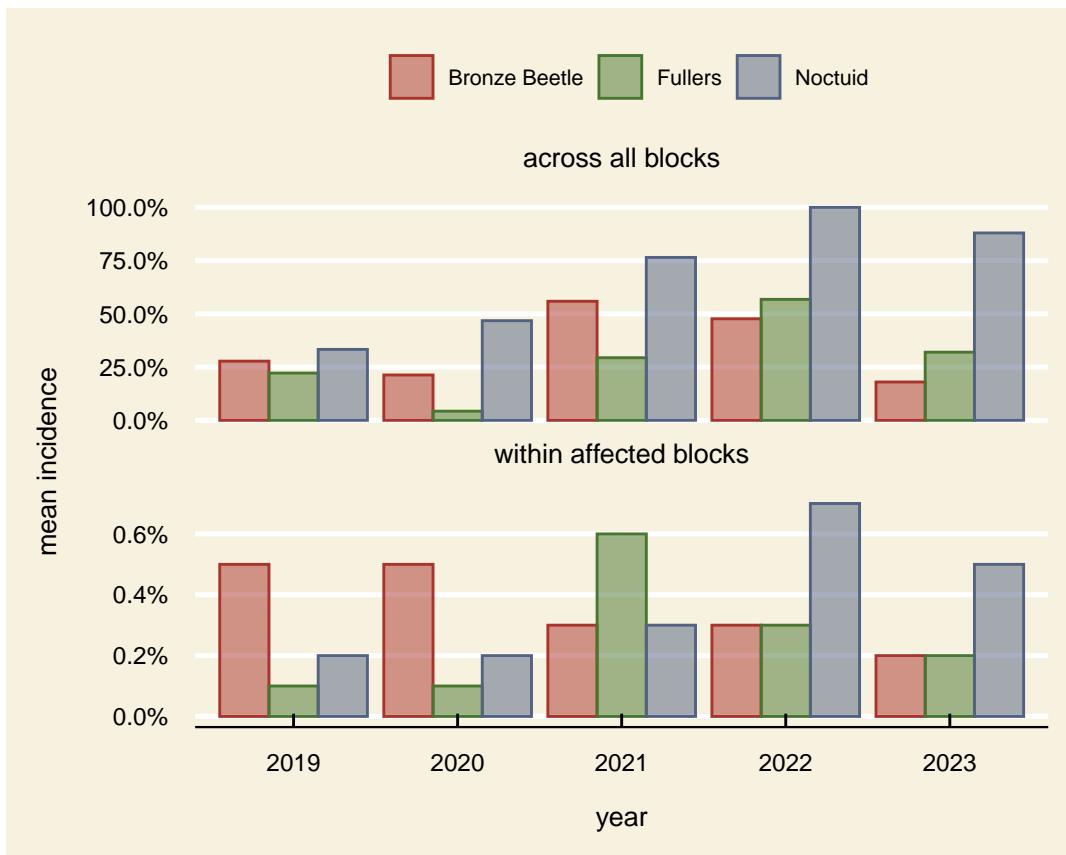


Figure 5.21: Average incidence of Bronze Beetle, Fuller's Rose Weevil and Noctuid moth in Rockit harvest assessment between 2019-23

## **5.13 Glossary**

**incidence** a measure of presence or absence of a pest and disease

**% Incidence** % Incidence - the percentage of blocks having a known P&D in their bin assessments

**P&D** Pest and disease

**P&D incidence within affected blocks** a measure of how bad P&D presence was within affected blocks

**average Incidence across all blocks** a measure of how widespread P&D presence was across all assessed blocks

**NZAPI** New Zealand apple and pears institute

**Movento** Chemical solution for controlling a range of sucking pests including ALCM, WAA and scale.

## **6 yield and fruit size prediction**

# 7 harvest and maturity management

Authors: Stuart Dykes, Dharini Marinkovich and Tim Channing Pearce

## 7.1 Introduction

Harvest commenced on 10<sup>th</sup> February 2023 and continued through to the 14<sup>th</sup> April spanning 63 days. A comparison of the of the 2022 and the 2023 season is given in Table 7.1. The major difference between the 2022 and 2023 season is the impact of cyclone Gabrielle which occurred over the 13 - 14<sup>th</sup> February 2023. Three days of apple picking were achieved before the cyclone struck and 414 bins were harvested. Harvesting resumed after the cyclone six days later on 18<sup>TH</sup> February. The gap can be seen clearly in Figure 7.1

Table 7.1: Summary statistics for 2022 and 2023 harvest timing

season	harvest date			bins			
	start	finish	length <sup>1</sup>	total	peak daily	days to peak	days with > 1,000
2019	2019-02-26	2019-04-18	51 days	11,866	751	14	0
2020	2020-02-24	2020-04-17	53 days	16,648	845	24	0
2021	2021-02-17	2021-04-14	56 days	21,932	926	13	0
2022	2022-02-15	2022-04-22	66 days	24,507	1,049	22	2
2023	2023-02-10	2023-04-14	63 days	28,734	1,118	27	4

<sup>1</sup> This also includes the six day gap in harvest cause by cyclone Gabrielle in 2023

## 7.2 Number of picks

Historically, Rockit™ apple orchards have been harvested multiple times during a season and multiple picks of an orchard is a relatively common practice, particularly with the 3D spindle growing system due to maturity differences within the tree. Reducing orchard picks A secondary reason was to allow the future estimation of pick numbers and to allow the optimisation of orchard picks to maximise productivity and quality.

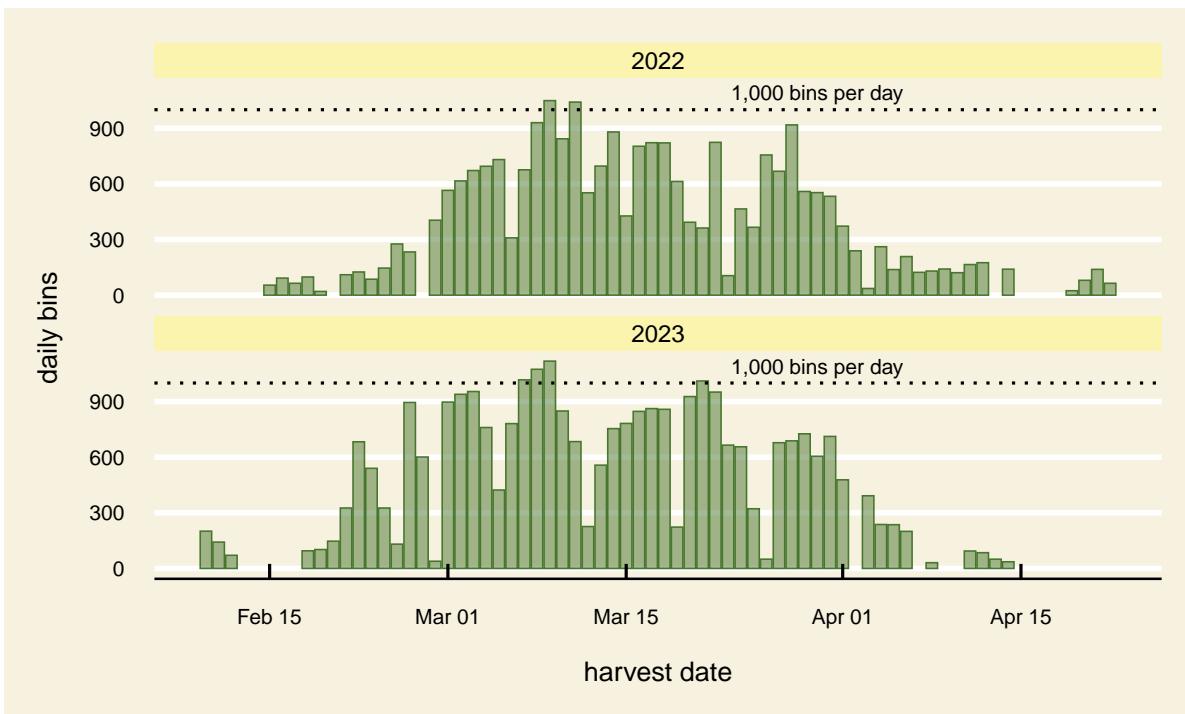


Figure 7.1: histogram of daily bins through the 2022 and 2023 harvest

Table @ref(tab:pickNoTable1) shows the number of blocks harvested in one, two or three picks. The same table also lists the bins harvested for each pick, depending on how many picks were required for the given block. Only 18 blocks were harvested once. This is likely due to orchard age and the small crop load. 80 and 79 blocks were harvested two and three or more times respectively. In terms of the number of bins per pick, these are given in absolute terms in table @ref(tab:pickNoTable1) and proportionally in table @ref(tab:pickNoTable2).

### Insight

This is an example of a callout with a title.

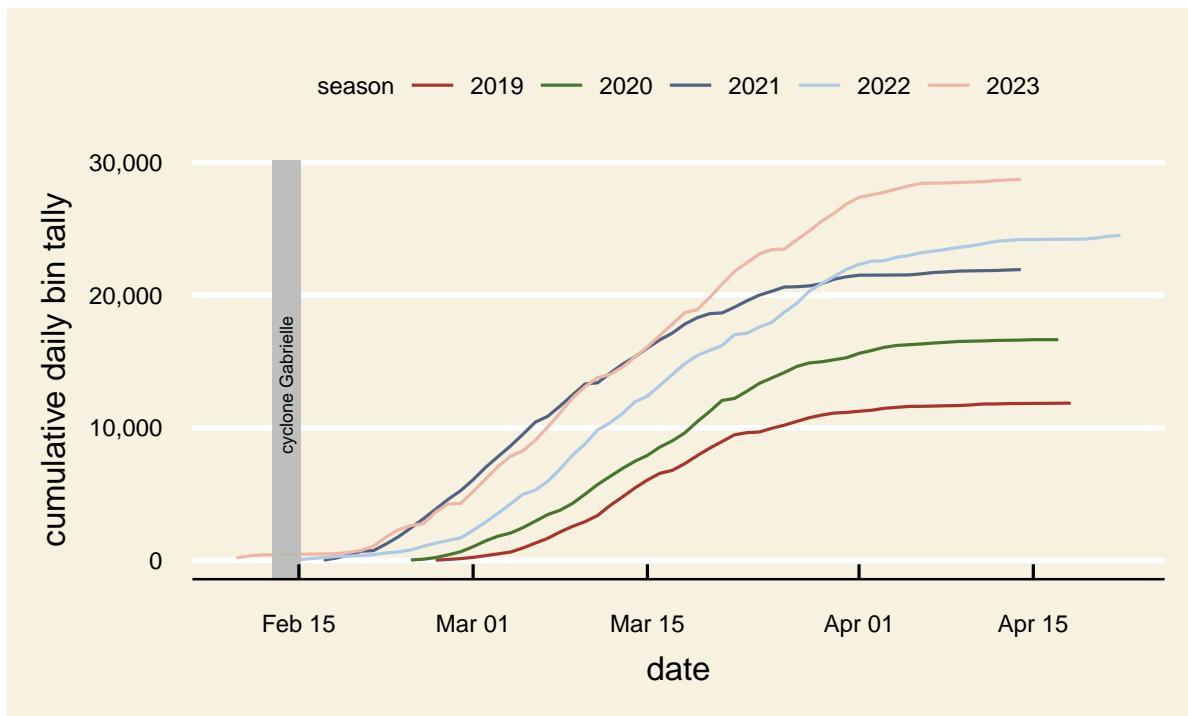


Figure 7.2: Comparison of cumulative daily bins since 2019

# 8 Yield Performance

Author: Stuart Dykes and Lachlan MacKay

## 8.1 Introduction

An annual analysis is performed to calculate the orchard yield (excluding pick-out). This is done to compare one season to another but also to validate the yield versus orchard age assumption used to calculate commercial returns when evaluating potential new orchard investments.

In 2023 Rockit orchards are grown using four types of systems:

- 3D spindle (top grafted)
- 3D spindle (own planted)
- 2D planar canopy
- FOPS planar canopy
- Twin leader

The extent of each planting style is given in table [Table 8.1](#) including the mean orchard age (weighted by planted canopy hectares). Approximately 40% of the planting are own-planted 3D spindle and a further 39% for 2D planar canopies. While the future orchard production system (FOPS) is only 4.5% of total (production hectares) in 2023, it represents considerable promise as a planar canopy that is well suited to PremA96. Depending on the performance of existing plantings, it is anticipated that additional PremA96 hectares will be planted using FOPS.

Table [8.2](#) gives the yields that are currently used for modeling orchard investments for 3D spindle, 2D planar and FOPS growing system. This table has been derived empirically based on historical data and/or theoretical estimates. This table can be directly compared to the observed yields achieved in 2023.

The yield analysis for 2023 has been complicated by the effects of cyclone Gabrielle. Extensive flooding across the region meant that many orchards could only be partially harvested. Some orchards lost 100% of their crop. In order to keep the analysis consistent, all flood affected orchards were removed from the data-set under analysis. This has affected, particularly the more mature 2D blocks .

### 8.1.1 Other exclusions

Hitherto the yield analysis has only looked for associations with a single predictor variable, namely orchard age. The analyses is then performed independently for each growing system. There are a number other co-variates that are likely to have a material impact on yield that have not bee factored, such as:

- soil type
- seasonal weather and climate
- root-stock
- orchard set-up (tree and row spacing)
- pruning and thinning - strategy and execution
- pest and disease pressure
- harvest management
- ...

Future analyses will begin to incorporate most or all of the variables using newly developed statistical and machine learning approaches to deliver a more accurate prediction of yield for a given set of parameters.

Table 8.1: Breakdown of New Zealand, producing PremA96 orchards by planting type and growing system

growing system	planting type	mean orchard age		planted area	
		years	Hectares	%	
2Dim	planted	2.8	327.8	38.7%	
3Dim	grafted	12.0	135.6	16.0%	
3Dim	planted	6.1	342.7	40.5%	
FOPS	planted	2.2	38.2	4.5%	
twin	planted	2.0	1.7	0.2%	

Table 8.2: Yield profiles for different growing systems currently used in investment models

orchard age	yield / tonnes/Ha		
	3D Spindle	FOPS	2D planar
0	0	0	0
1	0	0	0
2	0	9,000	9,000
3	21,658	18,900	18,900
4	40,936	37,800	33,300
5	56,406	56,700	56,700
6	64,022	76,500	76,500
7	66,878	85,500	85,500
8	66,878	90,000	90,000
9	66,878	90,000	90,000
10	66,878	90,000	90,000

## 8.2 3D spindle, own-planted

### 8.2.1 Introduction

The 3D spindle system is the traditional canopy that was adopted for PremA96. The management of this growing system is challenging due to the basitonic habits of PremA96 (Johnston, J, and Bryant, S. 2023) making the early development of the trees more labour intensive. From 2020 a decision was taken to only plant new PremA96 orchard developments in either 2D planar or FOPS canopy systems. The decision was made principally to facilitate the use of automation and orchard assist technology such as platforms.

Due to the relative ubiquity of the 3D spindle system for PremA96 there are several orchards that can be included in the analysis with a range of orchard ages. This allows a high quality curve to be modeled over the data. The details of the modeling are given in Section 16.3 and this approach is applied to all own-planted 3D spindle analysis. The model is based on fitting a logistic curve to the data using non linear least squares regression.

### 8.2.2 2023 by block

After removing all flood affected blocks, yields (mass of fruit harvested divided by canopy area) were calculated and plotted (Figure 8.1). A curve was then estimated using the methodology outlined in Section 16.3. The modeled result is overlaid as a curve in Figure 8.1.

Table 8.3: Regression parameters and confidence intervals for 2023 yield model, 3D spindle, planted by block

coefficients	mean	median	confidence intervals	
			lower 95%	upper 95%
$L$	42.9	42.8	38.5	48.0
$\alpha$	1.4	1.3	0.7	2.4
$x_0$	3.9	3.9	3.4	4.3

### 8.2.3 2023 by orchard

Yield was also evaluated by aggregated to an orchard or RPIN level. This is believed to be a superior measure as the planted areas are more consistent and the overall yields more balanced than when comparing individual blocks within an orchard. Despite the “smoothing” effect of the orchard aggregation, there is still considerable variability across

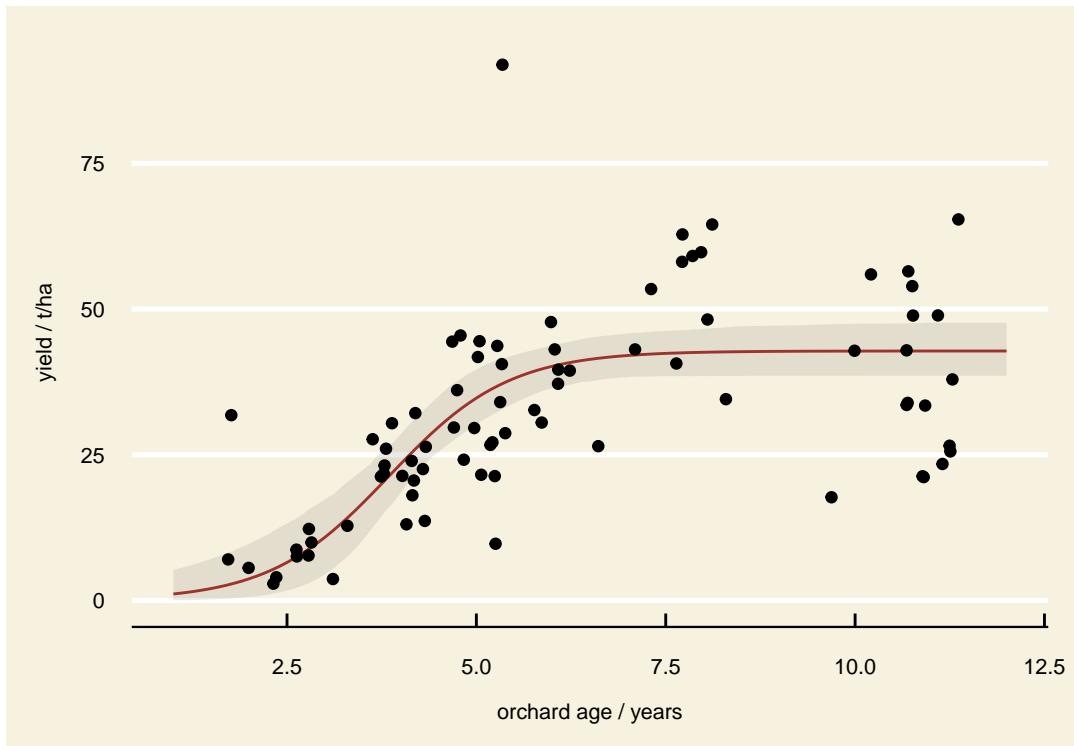


Figure 8.1: Yield as a function of orchard age for own planted spindle orchards in 2023 inclusive, grouped by block with individual block yields overlaid. The block names are not shown due to the number of data points but are given in the appendix

the orchards. The large variability in the orchard yields (Figure 8.2) is a function of various factors, believed to be:

- the initial condition of the trees
- the choice of rootstock
- the soil type
- the early canopy management decisions

Unfortunately the respective effects of these variables not easily quantified.

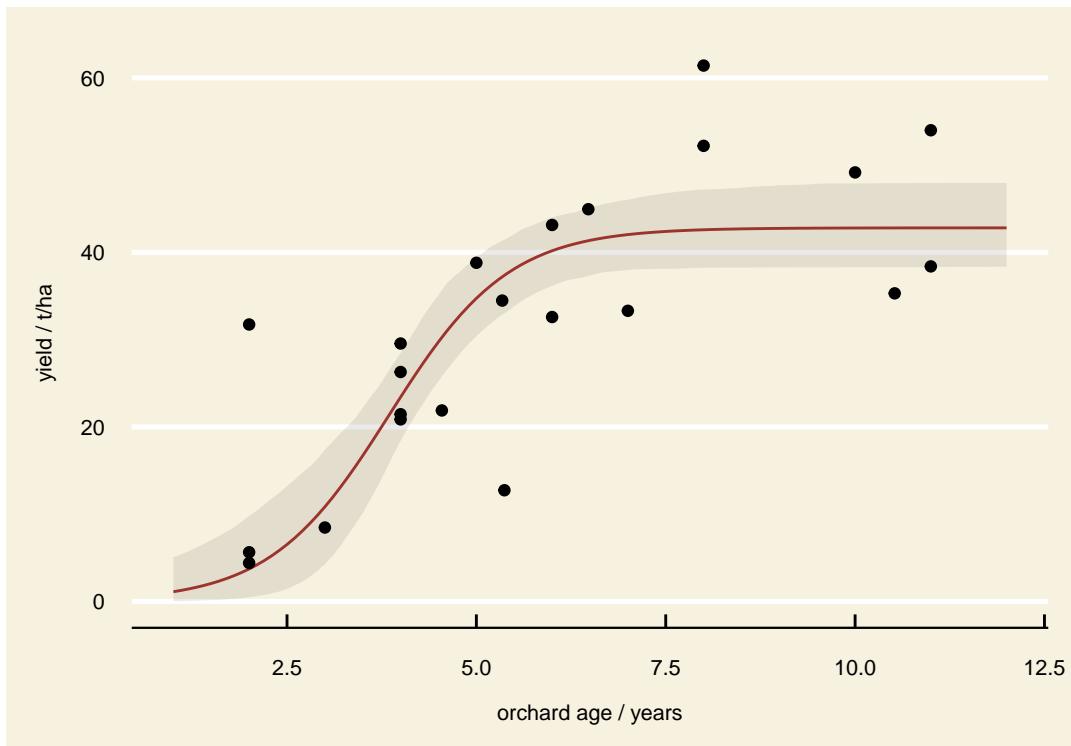


Figure 8.2: Yield as a function of orchard age for own planted spindle orchards in 2023 inclusive, grouped by RPIN with individual orchard yields overlaid

### 8.2.4 Three year summary by block

Table 8.4: Regression parameters and confidence intervals for 2023 yield model, 3D spindle, planted by RPIN

coefficients	mean	median	confidence intervals	
			lower 95%	upper 95%
$L$	51.8	49.1	40.2	72.7
$\alpha$	0.7	0.6	0.3	1.4
$x_0$	4.4	4.2	3.1	6.8

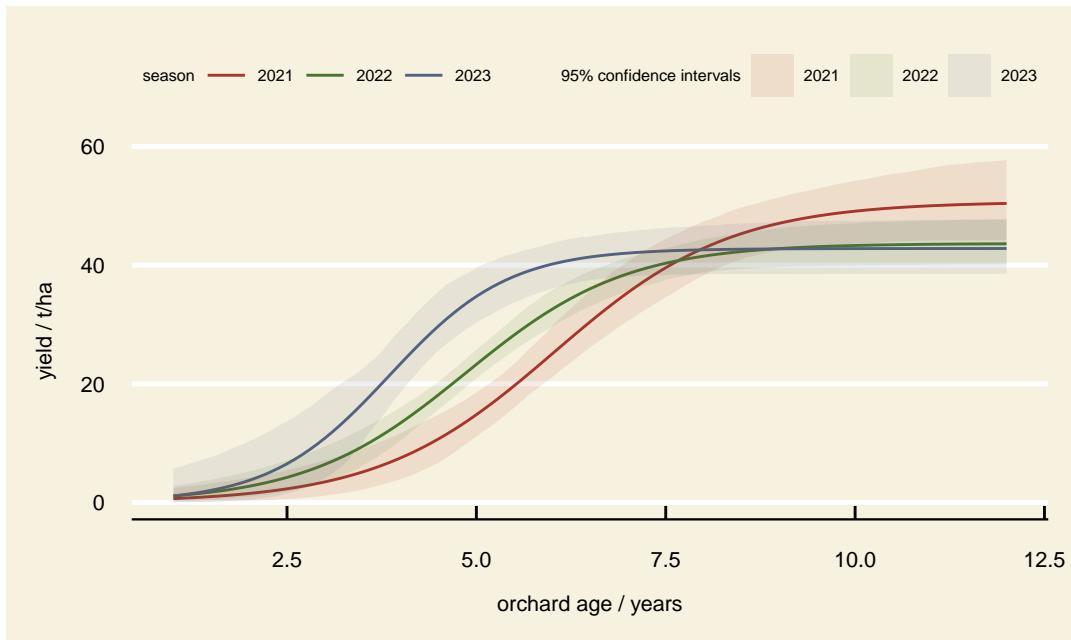


Figure 8.3: Yield as a function of orchard age for own planted spindle orchards 2021 to 2023 inclusive, grouped by block

Table 8.5: Regression parameters yield model applied to 3D spindle, planted by block, 2021 to 2023

coefficients	2021	2022	2023
$L$	50.70	43.66	42.81
$\alpha$	0.86	0.95	1.27
$x_0$	6.03	4.86	3.85

### 8.2.5 Three year summary by RPIN

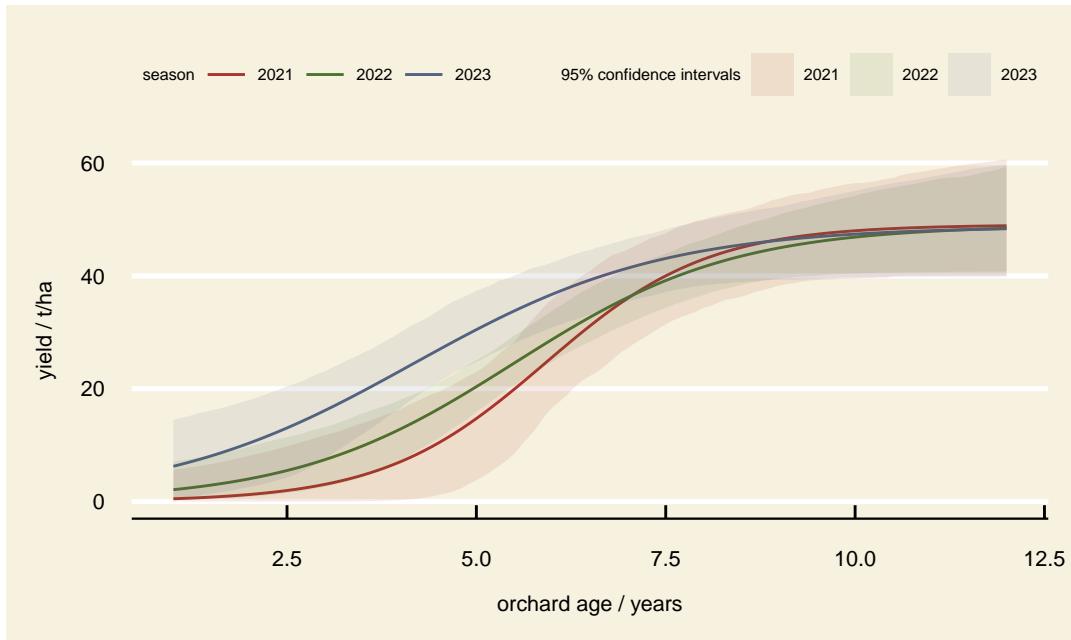


Figure 8.4: Yield as a function of orchard age for own planted spindle orchards 2021 to 2023 inclusive, grouped by RPIN (orchard)

Table 8.6: Regression parameters yield model applied to 3D spindle, planted by RPIN, 2021 to 2023

coefficients	2021	2022	2023
$L$	49.04	48.94	48.76
$\alpha$	0.93	0.69	0.61
$x_0$	5.91	5.49	4.16

## 8.3 2D Planar Canopy

As shown in Table 8.1 2D canopies now make up almost 40% of the planted Hectares of PremA96. The principal motivation for planting planar canopies (FOPS and 2D) are for increased gross yield per canopy hectare compared to 3D spindle and to allow for future orchard automation. In terms of the increased yield, this is yet to be validated to maturity (the oldest producing PremA96 2D orchard is only four years old). The yield results for the 2023 harvest for 2D canopies are shown in Figure 8.5. Note that only a single orchard

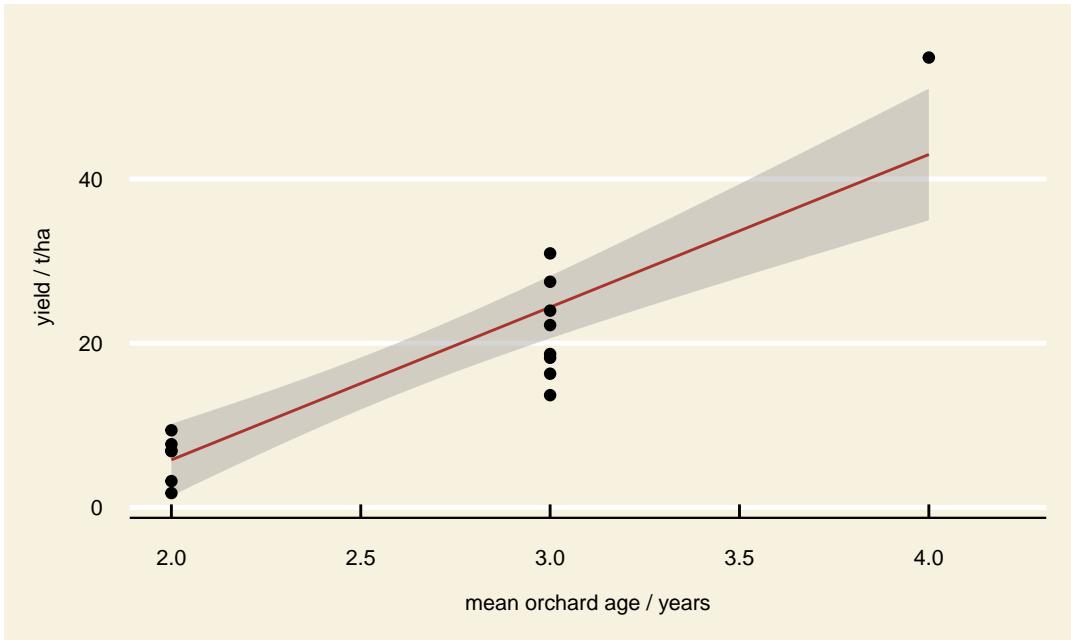


Figure 8.5: Yield as a function of orchard age for own planted 2D planar canopy orchards grouped by RPIN (orchard)

is shown at four years. The three 2D blocks that are one year older (Dartmoor, Korokipo and Korokipo Verries) were all significantly affected by Cyclone Gabrielle and have been excluded from the analysis.

A linear (least squares) regression was performed and overlaid on the orchard data in Figure 8.5. The regression summary is given in Table 8.7 and the modeled yield with orchard age is given in Table 8.8.

Table 8.7: Regression parameters yield model applied to 2023 2D planar, planted by RPIN

parameters	estimate	p.value
intercept	-31.40	2.26e-04
slope	18.60	1.66e-06

Table 8.8: Modeled yields for 2023 2D planar, planted by RPIN

orchard age years	yield tonnes/ha
2	5.80
3	24.39
4	42.99

## 8.4 FOPS

In 2023 only two producing orchards were using the FOPS system . The yields are given in table 9 and for both orchards exceed the estimated years for their respective orchard age. While this looks promising there are only two data points and no conclusions can be drawn about the mature yields that will be achieved.

Table 8.9: Yield as a function of orchard age for own planted FOPS planar canopy orchards grouped by RPIN (orchard)

orchard	orchard age	planted area	yield
	years	hectares	tonnes/ha
Home Block	3	11.2	26.08
Ormond Rd	2	11.7	8.73

## 8.5 3D Top grafted Canopies

The 3D top grafted canopies have become a legacy growing system but still represent 16% of total planting in 2023. The top grafts are of various types on various root- or inter-stocks. Figure 8.6 shows the relationship between yield and orchard age. There appears to be little association for these orchards and no attempt has been made to model one.

## 8.6 Discussion

3D Spindle canopies have traditionally been the prevailing growing system for PremA96. Initially these were top grafted blocks and more recently own-planted. The 3D spindle top grafted blocks show very little association with orchard age (Figure 8.6). This is

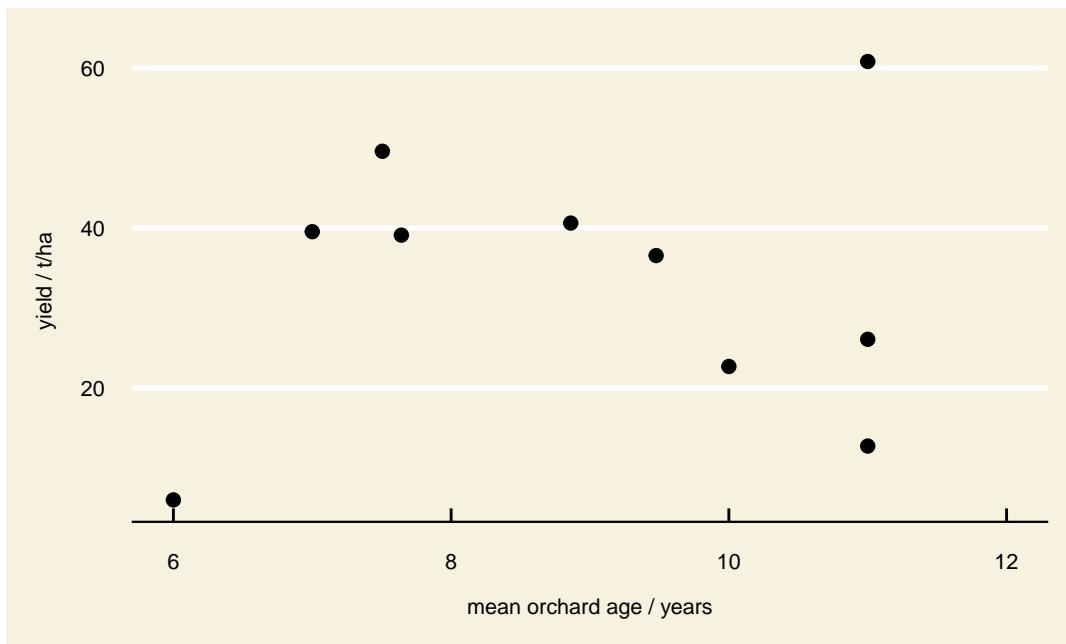


Figure 8.6: Yield as a function of orchard age for top grafted 3D canopy orchards grouped by RPIN (orchard)

understandable when the large range of orchard configurations, ages and conditions that provided the root- and interstock for the top-grafted trees. In terms of own-planted 3D sindle trees, these are able to be successfully modeled on both a block and an orchard basis. The orchard (as opposed to block) analysis is recommended as this is less prone to outliers and gives more consistent results. The yield curve is modeled by a logistic curve and the regression parameters show a high quality fit to the data. The modeled, mature yield for 2023 is calculated as 49.15 tonnes/Ha. This is similar to the 2022 and 2021 result (48.94 and 49.04 T/Ha respectively), and considerably less than the mature yield used in investment models (Table 8.2).

2D Planar canopies have been in the ground since 2018 and theoretical estimates have calculated mature yields at greater than 100 T/Ha. The theoretical yield profile for both 2D and FOPS canopies are given in Table 8.2. The 2023 results (Table 8.8, Table 8.9) shows that in the case of both FOPS and 2D the yields achieved are exceeding the investment model. It should be noted that in the case of FOPS there are only two data points, and in the case of both planar canopies more season will need to be evaluated to build confidence in the model

## **8.7 Glossary**

## **9 storage**

# **10 quality and phytosanitary performance**

Authors: Stuart Dykes & Anna Duly

## **10.1 Introduction**

The 2022/2023 season was challenging not just because of cyclone Gabrielle in February but also the very warm and wet spring and early summer which led to high levels of pathogenic inoculum such as black spot (*Venturia inaequalis*) and botrytis (*Botrytis cinerea*). Conditions were also favourable for apple leaf curling midge (*Dasineura mali*) and various forms of mealy bug (with long tail mealy bug [*Pseudococcus longispinus*] being the most prevalent). The wet spring also facilitated the proliferation of russet (non-pathogenic) which contributed x% of all rejects.

Black Spot, ALCM and Mealy bug are a particular problem in that an entire batch can be excluded from a critical market (e.g. China, Taiwan, Japan) if a single incidence is detected.

The aim of this report is not to analyse and evaluate all observed defects and disorders, but only those that impact the ability of Rockit™ apples to enter key markets, most restrictive of all are Taiwan and China. Where possible, comparisons are made against previous years performance.

## **10.2 Phytosanitary regulation process**

Rockit Trading Company (RTC) exports to jurisdictions that have Official Assurance Programmes (OAPs). These provide a prescriptive set of instructions to follow in order to be able to export to that particular jurisdiction. The OAPs include the grower requirements, Pack-house requirements (including registration), packing requirements (including detailed inspection regimens (Thomson, Peter 2015)), storage and export requirements (including active registration). A specific register of excluded pests, diseases and disorders and their respective threshold are listed. OAPs exist for the following jurisdictions:

- Australia
- West Australia

- China
- Japan
- Russia
- Thailand
- Taiwan

Of these seven areas, RTC actively exports to three (China, Japan and Taiwan). Of these three, Taiwan is the most restrictive and prescriptive and therefore is the OAP that is used to set the phytosanitary programme for Rockit Packing Company (RPC) (Olsen, Shane 2022).

### **10.2.1 Exclusion from OAP markets**

given the proportion of the fruit volume that is sent to Taiwan and China by RTC, the requirement to comply with the OAPs is critical for the ongoing success of Rockit™ Apple. Market exclusion to China and/or Taiwan can occur for various reasons, most commonly is the interception of pests, diseases and disorders that appear on the pest register detailed in a document called the Importing Countries Phytosanitary Requirements (ICPR) which is specific for each jurisdiction and is referenced by the OAP. The identification of phytosanitary issues occurs during packing where a designated proportion of fruit is specifically inspected for the pests and diseases detailed in the ICPR (Ministry for Primary Industries 2000). The ICPR also states the rejection threshold for each (e.g. < 2%). If interceptions are encountered and the threshold is met, the batch will be excluded from the OAP market(s). The sampling programme and the acceptance sampling criteria are detailed in The Technical Standard: Phytosanitary Inspection (Thomson, Peter 2015)

### **10.2.2 Orchard and post harvest facility registration**

OAP market access can also be excluded if the particular production site has failed to register for export to the specific market. Similarly the pack-house and cool-store also require official registration. There are a number of criteria (e.g. good agricultural practice certification - Global GAP) required to be able to register. Registration of orchards must be completed by the 1<sup>st</sup> September; pack-houses and cool-stores registration by 1<sup>st</sup> October. In the case of China, export is only allowed when the Chinese authorities verify and publish the approved register which may be after the start of packing. If the initial registration has only been the year before the fruit is harvested. For new orchards, it is therefore highly recommended to register the production sites the same year the block has been planted.

### **10.2.3 Rockit imposed exclusion criteria for 2023**

In addition to the exclusion criteria mandated by the OAP, RTC has imposed additional rules to minimise the risk of a border interceptions in China and Taiwan, due to the increased sensitivity this year. These include:

- Remove the consignment from the market if more than three MPI lots are excluded for the same pest.
- ...

## **10.3 Review of the 2022/2023 growing season**

The 2022 and 2023 growing seasons were characterised by relative cool wet weather. Figure 10.1 and Figure 10.2 show the cumulative rainfall, temperature profile for 2022, 2023 and the full bloom period of the 2024 season. As can be seen from fig-cumrain, the rainfall was persistent over the 2023 growing season, compared to 2022 where the rain came later in the season with an extreme rain event from the 20-24th March (mid-harvest). While there has been some rain in late 2023 it has not been as extensive as 2023 growing season. Note the extended full bloom window in 2022, which was driven by a very warm winter. contrast this with the relatively short full bloom window in 2023 on the back of 2785 additional Richardson chill units compared to 2022.

## **10.4 Post harvest pest interceptions**

In terms of pest interceptions, the 2023 season was prolific compared previous seasons. Figure 10.4 shows the temporal distribution of pest interceptions through the packing seasons (2021 through 2023). The number of interception in 2023 was considerably greater than in either 2021 or 2022. The mix of pests and disorders was also quite different with three main disorders prevailing: ALCM, black spot and long tailed mealybug.

### **10.4.1 black spot**

The incidence of black spot could be predicted from:

1. The weather, particularly the period from full bloom to the end of January.
2. The prior levels of inoculum in the respective orchard.
3. The visual incidence of disease during inspection in November/December (Drinnan, Svetlana (2023))

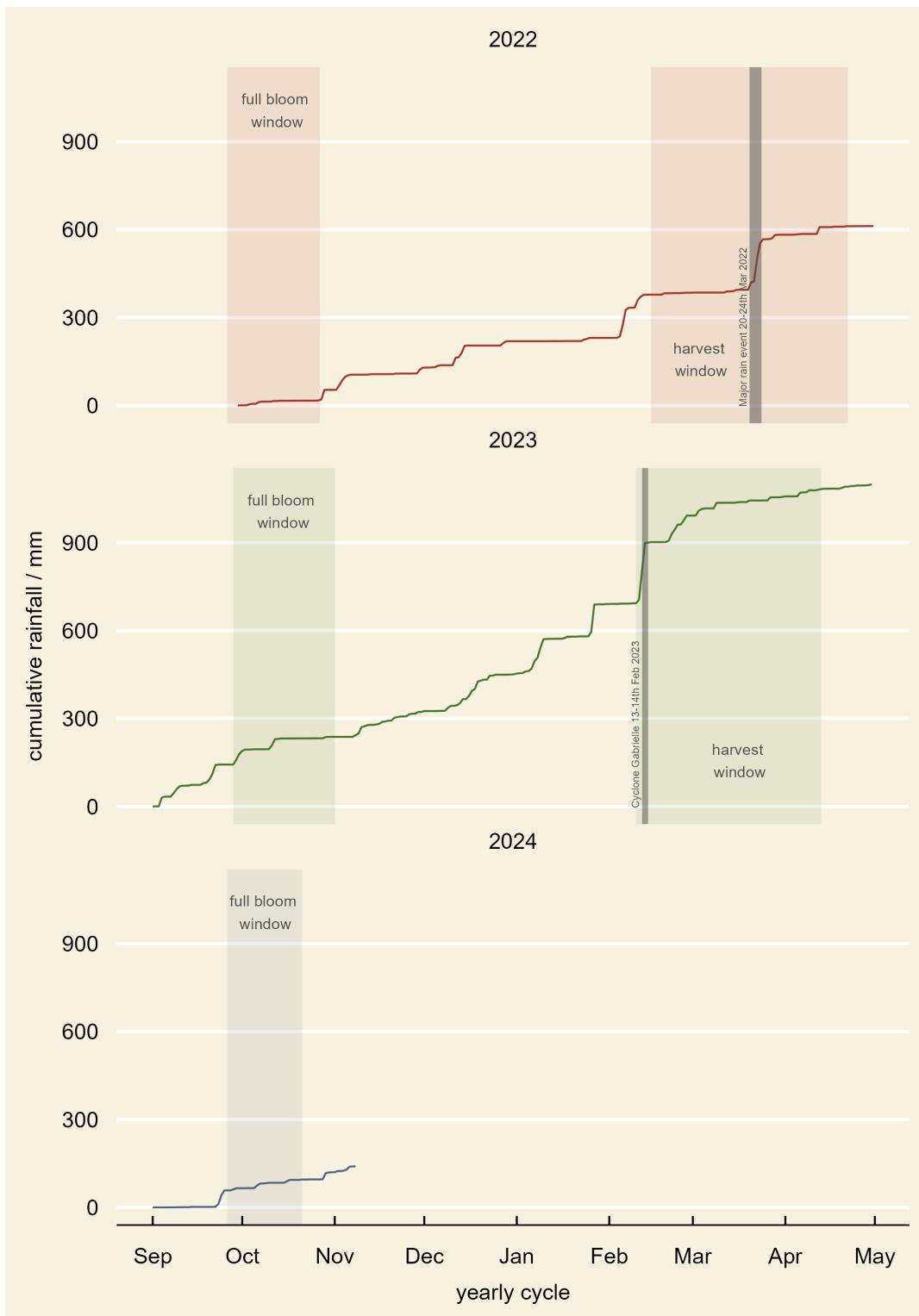


Figure 10.1: cumulative rainfall over the growing seasons 2022 through 2024 (YTD). Full bloom and harvest windows are overlaid for each season as well as the two extreme weather events in 2022 and 2023

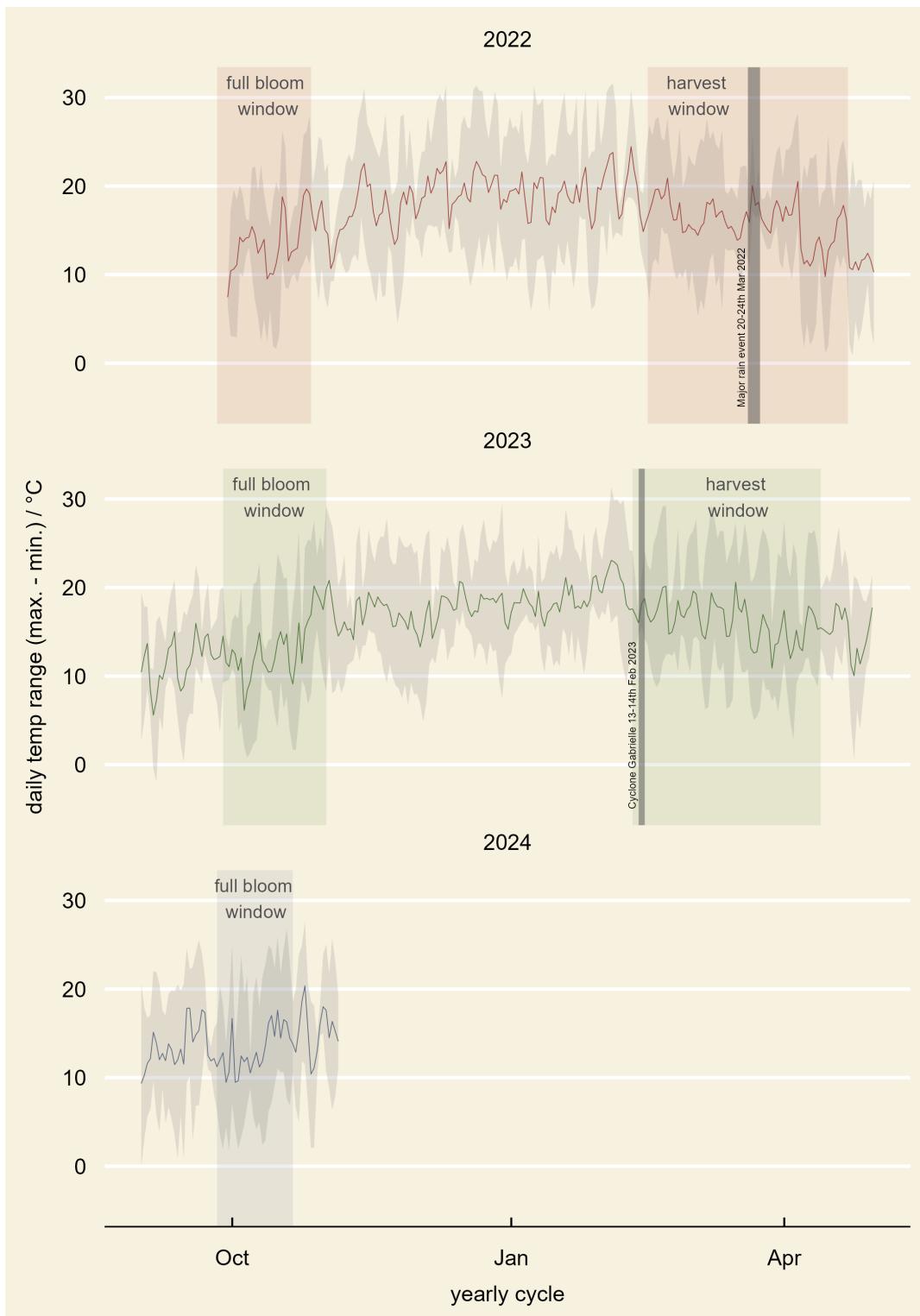


Figure 10.2: temperature profile over the 2022 - 2024(YTD) growing seasons. The solid line represents the mean daily temperature and the grey ribbon either side of the line is the diurnal variation. The full bloom and harvest windows are overlaid as well as the two extreme weather events the occurred in 2022 and 2023

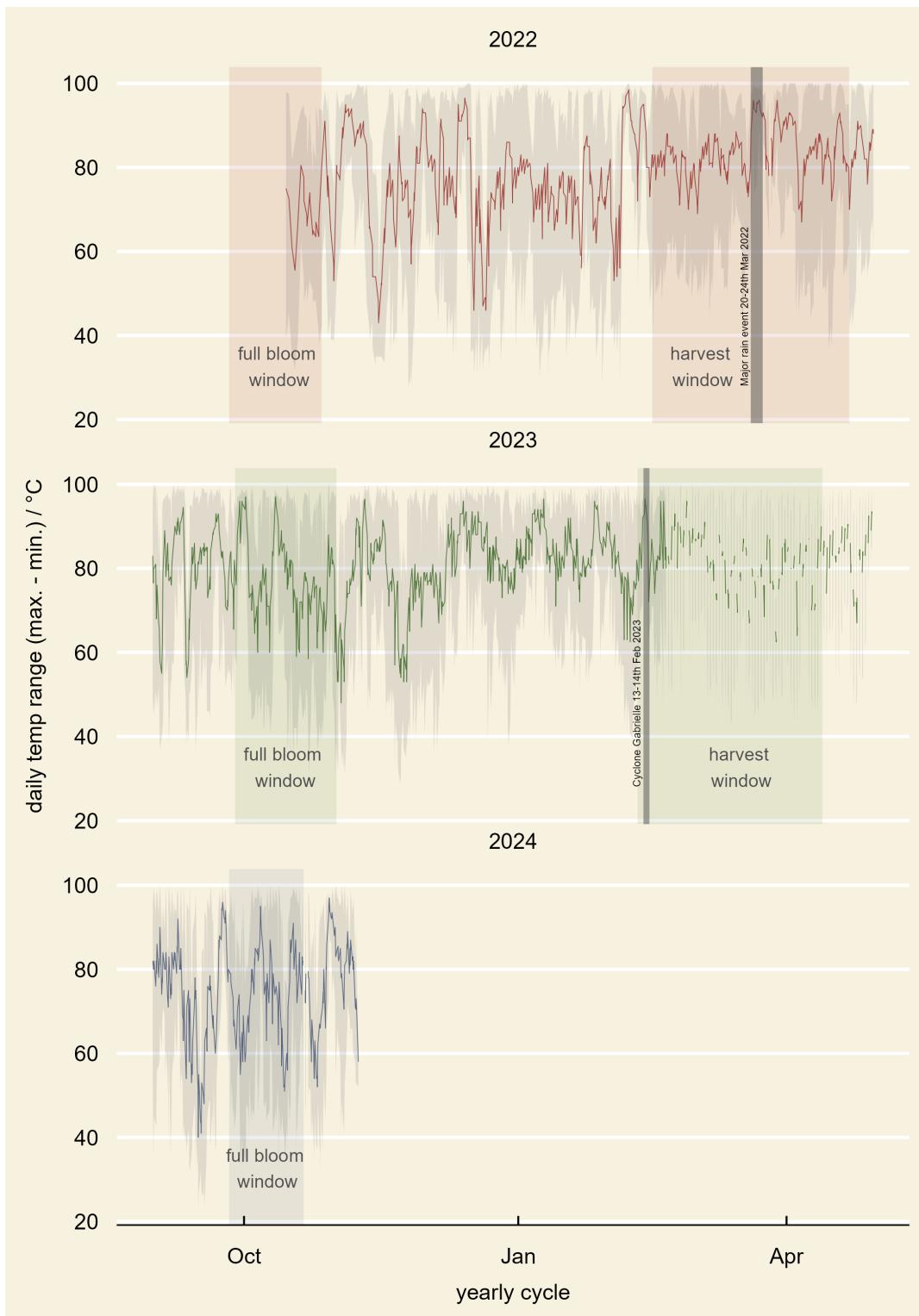


Figure 10.3: Daily relative humidity readings 2022 - 2024 (YTD) growing seasons. The solid line represents mean daily humidity and the grey ribbons to either side show the maximum and minimum humidity readings respectively. The full bloom and harvest windows are overlaid as well as the two extreme weather events in 2022 and 2023.<sup>82</sup>



Figure 10.4: number of pest interceptions during the post-harvest packing, 2021 through 2023 inclusive

The visual incidence during the November and December inspections was considered elevated with up to almost 3% in one orchard. Rockit™ apple's black spot incidence across all blocks has almost doubled in 2023 harvest assessments compared to the previous season, mainly due to increased numbers of bin assessments at orchards with known disease presence from spring assessments. Assessing risk factors against spray programme is recommended for these blocks to see where errors might have happened, i.e. equipment (rates and calibration), timing with respect to weather conditions (coverage and drying times), product (resistance possibilities).

While the integrated disease models are available through the Metris application, it is unclear whether these are being used systematically across all orchards. This would give valuable assistance in identifying periods of high infection risk.

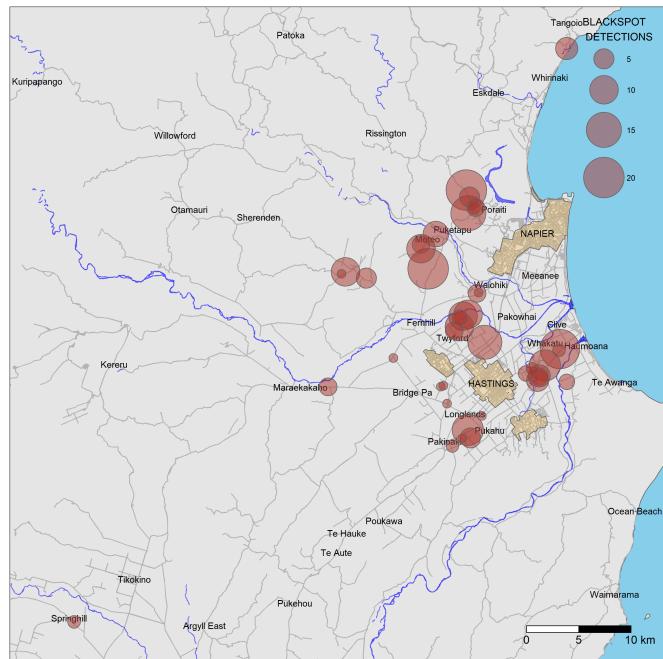
The spatial distribution of black spot in both Hawkes Bay and Gisborne region is shown in Figure 10.5. This shows the infection is wide spread in the Hawkes Bay and significant infections isolated to three orchards in Gisborne.

#### **10.4.2 Blackspot infection modeling**

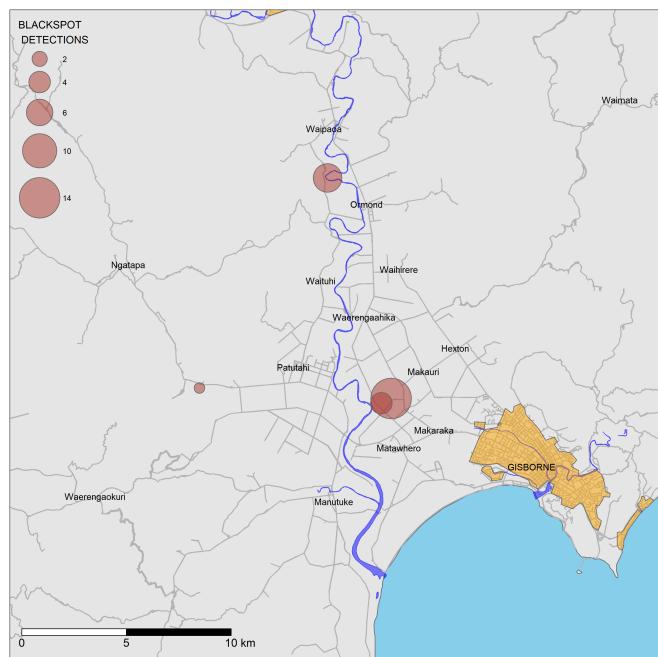
Given the prevalence of black spot (*Venturia inaequalis*), considerable research has been carried out in many apple growing areas around the world including extensive work that has been carried out in New Zealand (MacHardy (1996); R. M. Beresford and Spink (1992); R. M. Beresford and Manktelow (1994); R. M. Beresford, Henshall, and Palmer (2004); R. M. Beresford and Mackay (2012)). The fungi overwinters in the dead and infected leaves which gather on the orchard floor beneath the trees. In the spring the spores mature and there are three principal drivers:

1. the average temperature while the spores are maturing
2. the average temperature while the leaves are wet and
3. the length of the wetness period

The ascospores develop during the accumulation of the growing degree days. It is assumed that all ascospores have matured at 534 degree days (MacHardy (1996)). The release of the ascospores is dependent on weather (specifically daylight and leaf wetness). Once spores are released and move onto the secondary phase of the infection which involve canidia that germinate on the fruit or leaf surface causing black lesions. The duration of the infection period, and average temperature are inversely related; that is the higher the temperature the shorter the duration required for an infection. Infections are rated: marginal, light, moderate and severe based on the wetness duration and temperature. Figure 10.6 shows the significant infection events (i.e. greater than marginal) for 2022 and 2023 broken down by region in Hawkes Bay. It clearly shows that the black spot pressure was greater in 2023 than 2022, in terms of the primary infection.



(a) Hawkes Bay



(b) Gisborne

Figure 10.5: regional spread of black spot detections in 2023

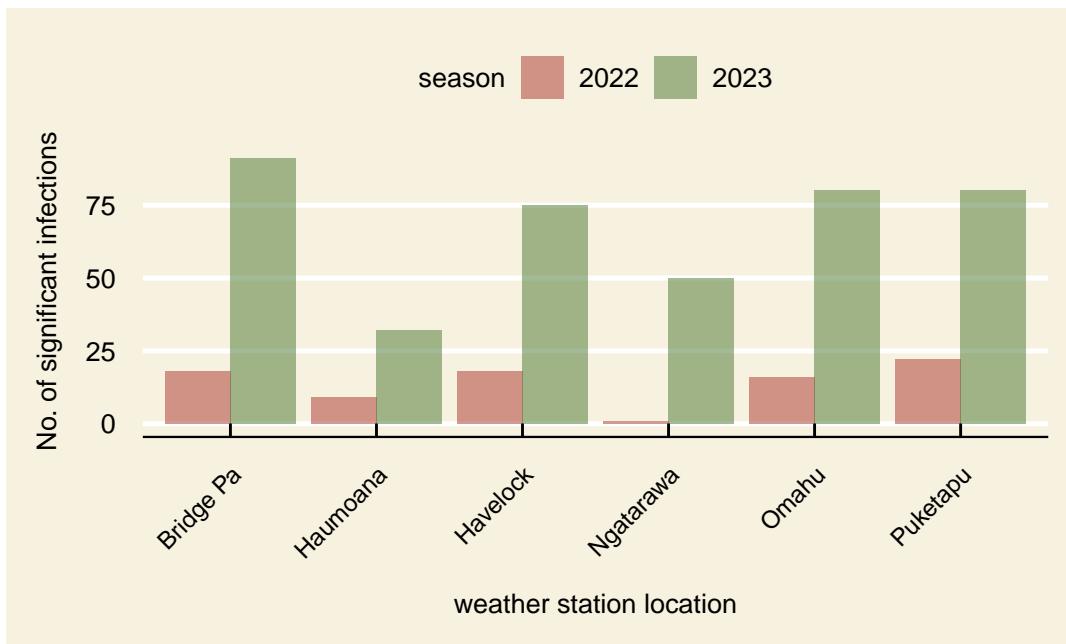


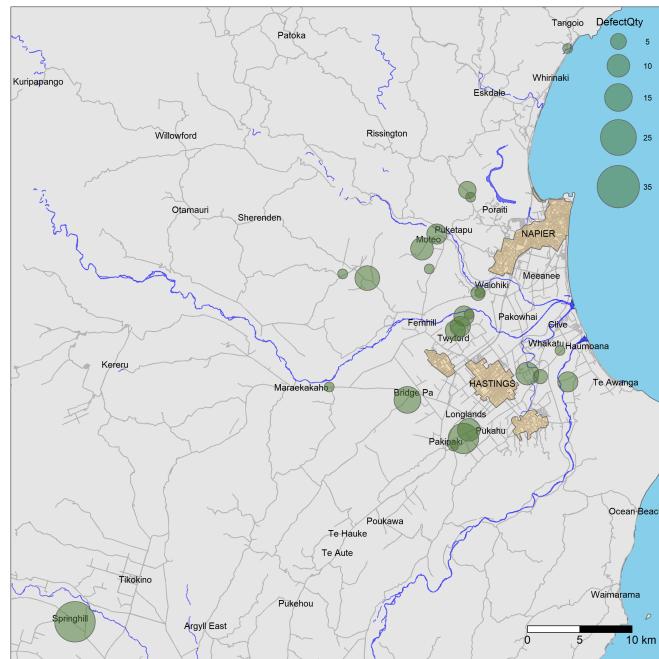
Figure 10.6: Comparison between 2022 and 2023 of the number of primary blackspot infections for the period between 1st Oct to 1st April

#### 10.4.3 apple leaf curling midge (ALCM)

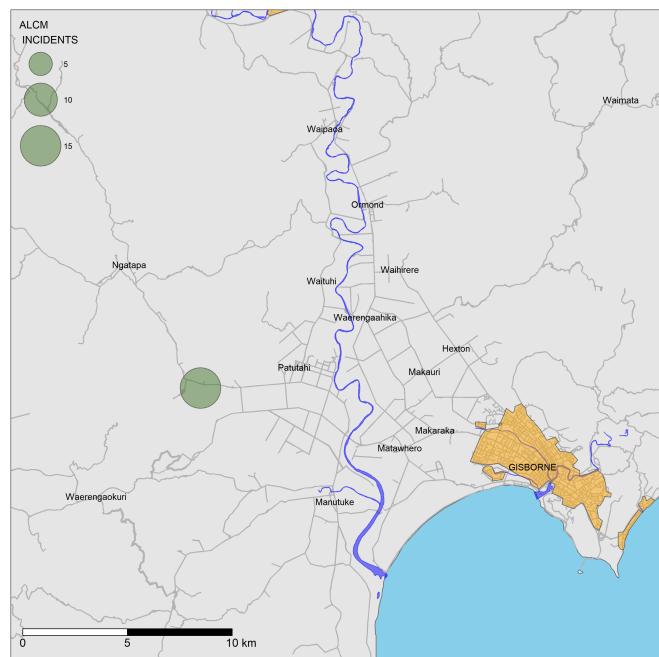
Apple Leaf Curling Midge (ALCM) is quarantine pest for China, Japan with Maximum Pest Limit (MPL) 0.5%. Access to Taiwan relies on nil detected ALCM.

ALCM is a difficult pest to control. Effective control can only be achieved when several strategies are used collectively with each other: on orchard monitoring for tree vigour and new shoot damage, Movento applications and fruit assessments for ALCM pupae presence. Although, traditionally monitoring for ALCM is done in summer (post 3rd midge generation, G3), knowing ALCM presence on orchards from generations 1 (G1) and 2 (G2) can assist in control strategies with focus on G3 to minimise export risk.

Pre-harvest ALCM assessments predicted that despite significant incidence of ALCM infection, the risk of a “bug-out” during packing was unlikely. Despite the analysis, ALCM interceptions during packing were prolific in 2023 (compared to 2021 and 2022) as shown in Table 10.1. The regional distribution of ALCM in 2023 is shown for both Hawkes Bay and Gisborne regions in Figure 10.7.



(a) Hawkes Bay



(b) Gisborne

Figure 10.7: regional spread of ALCM detections in 2023

Table 10.1: Number of MPI lots facing market exclusion, by disorder, for 2021 through 2023

disorder	harvest year		
	2021	2022	2023
ALCM	3	12	81
Codling Moth	3	1	0
Black Spot	30	72	243
Woolly Apple Aphid	12	5	14
SanJose	16	6	3
Citrophilus Mealybug	20	11	5
Obscure Mealybug	2	1	1
Glomerella (Bitter Rot)	1	0	2
Long Tail Mealybug	2	6	52
Eye Rot/Canker rot	8	1	4
N.Alba	1	0	5
WHITE ROT	0	1	0
Alternaria	0	1	2
Phytophthora	0	0	3

## 10.5 Process change in the pack-house

In addition to the high pest pressure in the region, a change in process was applied in the pack-house that likely had an impact on the number of lots that were excluded from OAP markets. The change involved nominating MPI lot sizes prior to packing to comply with the OAP. These “MPI lots” were set nominally at 25 bins, hence the distribution of the number of MPI lots per batch has changed from 2022 to 2023 packing season. The change can be visualised by bar chart in Figure 10.8

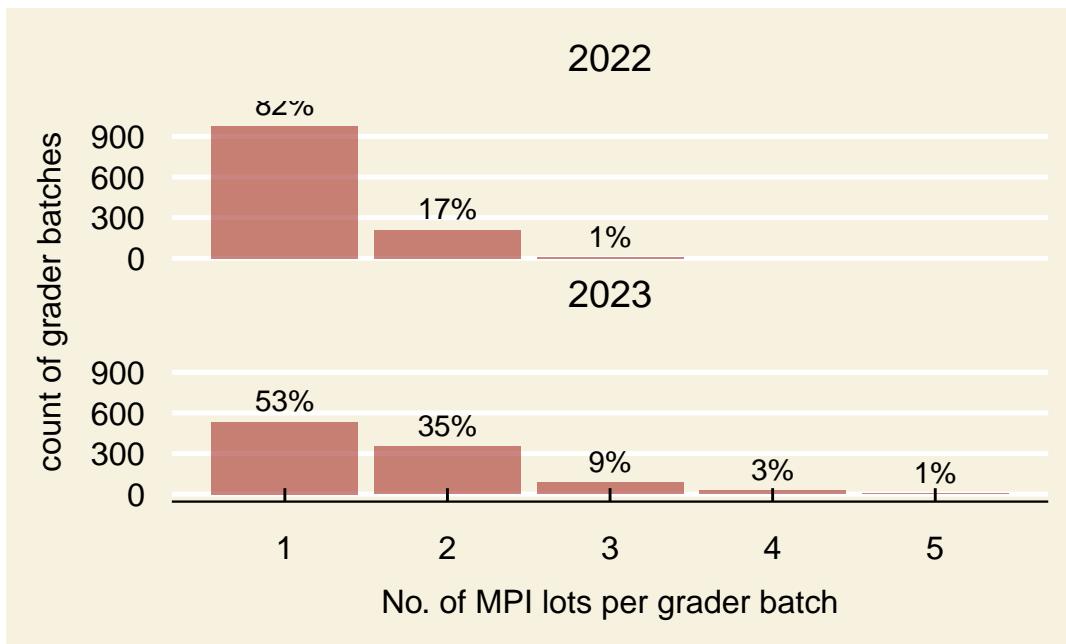


Figure 10.8: Comparison of number of MPI lots per grader batch for packing seasons 2022 and 2023

## 10.6 Conclusion

## **10.7 Glossary**

## **11 packhouse performance and the impact of automation**

## **12 fruit size and SKU mix**

## **13 stock on hand and inventory performance**

## **14 in market quality**

# 15 Summary

In summary, this book has no content whatsoever.

1 + 1

[1] 2

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# 16 Appendices

## 16.1 Growing degree days

$$GDD = \sum_i^K \frac{T_i^{max} + T_i^{min}}{2} - T^{base} \quad (16.1)$$

Where:  $i$  = ith day

$K$  = total number of days summing over

$T_i^{max}$  = the maximum daily temperature on the ith day

$T_i^{min}$  = the minimum daily temperature on the ith day

$T^{base}$  = the base temperature for the model (in our case 10°C)

## 16.2 Chill units

The models used to predict chill requirement are empirically based and difficult to validate. Rockit tracks two models: Chilling hours and the Utah model (also known as Richardson Chill units). These are best described mathematically in equations Equation 16.2 and Equation 16.3 respectively.

$$CH_i = \sum_i^t T_{7.2} \text{ where } T_{7.2} = \begin{cases} 0^\circ C < T < 7.2^\circ C & : 1, \\ \text{else.} & : 0 \end{cases} \quad (16.2)$$

Where:

$i$  = ith hour

$t$  = total number of hours summing over

$$RCU_i = \sum_{i=1}^t T_U$$

$$\text{where } T_U = \begin{cases} T \leq 1.4^\circ C & : 0, \\ 1.4^\circ C < T \leq 2.4^\circ C & : 0.5, \\ 2.4^\circ C < T \leq 9.1^\circ C & : 1.0, \\ 9.1^\circ C < T \leq 12.4^\circ C & : 0.5, \\ 12.4^\circ C < T \leq 15.9^\circ C & : 0, \\ 15.9^\circ C < T \leq 18.0^\circ C & : -0.5, \\ T > 18.0^\circ C & : -1.0 \end{cases} \quad (16.3)$$

Where:

$i$  = ith hour

$t$  = total number of hours summing over

The chilling hours model takes the average temperature every hour and assigns an index of either one if the temperature is between  $0^\circ C$  and  $7.2^\circ C$  and zero if the temperature is outside that range. Daily totals are aggregated and the cumulative chill units over the dormant period are tallied. The Utah (Richardson) model uses a similar approach but provides weightings to various temperature ranges. These are detailed in equation Equation 16.3. Note that the weightings for the higher temperature ranges are negative which means that cumulative chill units can decrease as well increase; this reflects the reversible nature of the hormone accumulation in the apple buds (Sheard, Andrew G. 2001).

## 16.3 Yield modeling

### 16.3.1 Modeling of 3D Spindle yields

Yield for many biological systems can be described by a logistic growth model, slow to begin, a period of rapid growth then a period where the growth asymptotes to a steady state maximum value. A mathematical description of the logistic model is given in (Dykes, Stuart 2021). yield as a function of orchard age for planted, 3D spindle trees can be given Equation 16.4:

$$f(t) = \frac{L}{(1 + e^{-\alpha(x-x_0)})} \quad (16.4)$$

where:

$f(t)$  = yield as a function of orchard age

$L$  = maximum asymptotic yield

$\alpha$  = rate constant

$x$  = orchard age

$x_0$  = growth midpoint

Yield can be affected by a number of different influences, inter alia: the age of the trees, growing system, root-stock choice, seasonal effects and management decisions. In the analysis below yield is treated as a response, or outcome variable with orchard age as the principal predictor variable. The effects of growing system is accounted for by performing a separate analysis for the 2D and 3D canopies. The effect of top-grafted blocks has also been removed by only including planted orchards in the analysis.

### 16.3.2 Methodology

Yield is calculated simply by taking the total mass of fruit harvested (in tonnes) and dividing by the canopy hectares. No attempt has been made to correct for the effect of pick-out (the fruit that is left on the orchard floor or on the tree after harvest). Two analyses are carried out:

1. yield by individual block
2. yield by total orchard (RPIN)

The modeling was carried out using the non-linear least squares regression function as part of R's **stats** package (**R-base?**). The regression parameters and confidence intervals were calculated using non-parametric bootstrapping through R's **nlsBoot** function from the **nlsTools** package. All analysis code is contained within this markdown document.

The approach was to analyse the last three years of harvest data, 2020 through 2022. The first analysis was to examine block data (i.e. the sub-block of an orchard) which provide a greater data set but more variability, given block areas can be less than one hectare. The second analysis was to aggregate the blocks within an orchard together and calculate the orchard yield for the total orchard. This provides a more robust yield measurement as the orchard area will be larger than the block area, however, the inter-block variation is masked.

The final activity is an examination of the 2D canopy yield. There are currently four productive PremA96 orchards on a 2D canopy (planted in 2018 and 2019) and in 2021 only two data points were available making any prediction of terminal yield difficult.

The data used for all analysis was taken directly from the **ABCpacker** SQL Server tables using R's **odbc** and **DBI** packages. The data manipulation was carried out using the **tidyverse** package.