CHAPTER FOUR
SCIENCE AND SUSTAINABILITY

Over the past few years, the kiwifruit industry has vastly increased its focus on sustainability. Consumers are expecting more from businesses in terms of sustainability – they care about what their food is wrapped in and want to know more about where it comes from and that it has been grown in a way that enhances the environment and support livelihoods. As well as investigating some of the drivers of sustainability, this chapter focuses on some of the science topics that support this.

THE SECTION IS DIVIDED AS FOLLOWS

4.1 THE DRIVERS FOR SUSTAINABILITY

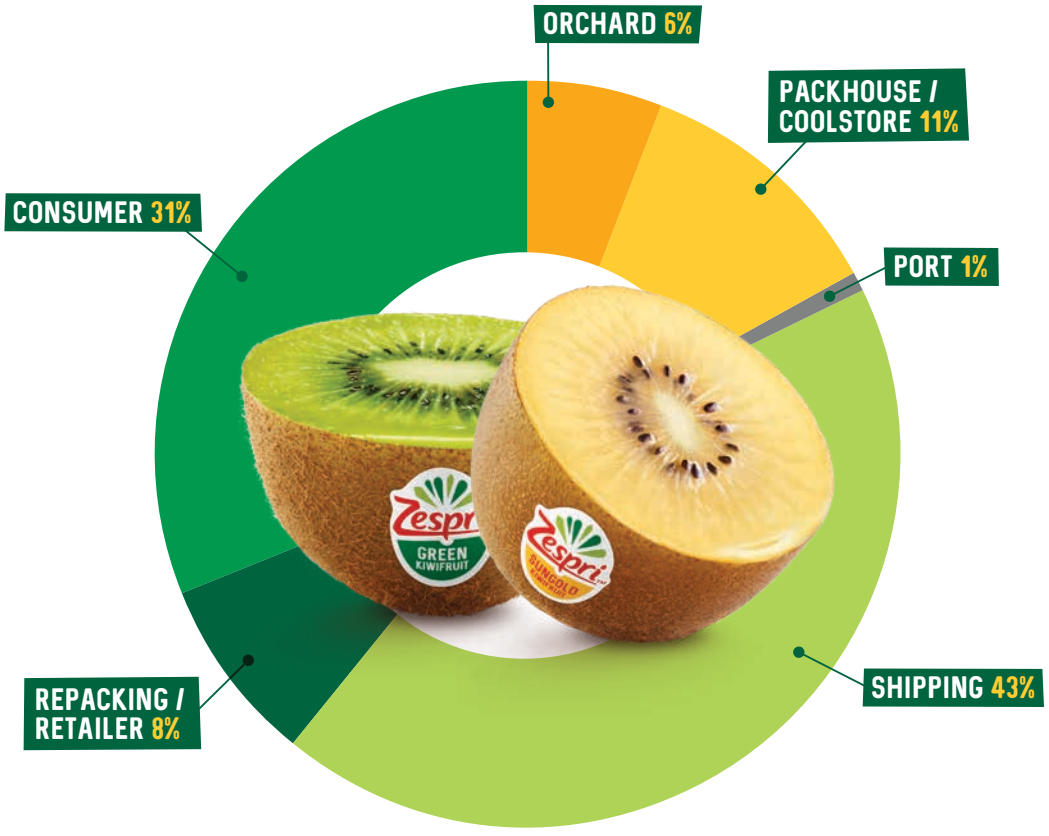
In the mid-2000s, global retailers were challenged by non-government organisations to reveal the environmental cost of sourcing products. At that time, kiwifruit was cited as an example of a product that was grown, stored and shipped long distances to be sold in Europe. By partnering with government, including the Ministry of Foreign Affairs and Trade and the Ministry for Primary Industries, Zespri co-funded research on determining the carbon and water footprints for kiwifruit grown in New Zealand and consumed in Europe.

Carbon footprint represents the amount of greenhouse gas emissions associated with an organisation, event or production. An increase in greenhouse gas emissions is the primary driver of global warming and climate change. In NZ, the main greenhouse gas is methane from agriculture. For horticulture, including kiwifruit production and distribution, the main greenhouse gas is carbon dioxide.

Essentially, the findings highlighted that the environmental impacts of New Zealand kiwifruit were comparable to those of competitors, including kiwifruit grown within Europe. This information was then communicated to Zespri's retail customers, where it helped alleviate major concerns about New Zealand's Kiwifruit. This example highlighted to the kiwifruit industry that there was a need to better understand the environmental impacts of kiwifruit so that Zespri could respond more quickly to any questions related to this topic from the markets or local communities.

CONTRIBUTION OF EACH STAGE

In the supply chain to the carbon footprint of Zespri Kiwifruit produced in New Zealand and consumed globally (2017 crop).



4.2 ZESPRI'S SUSTAINABILITY PRIORITIES

In 2010, Zespri developed a strategy to manage the environmental risks associated with fresh kiwifruit production and consumption. At that time, the top five globally important environmental impact areas were identified. These areas were greenhouse gas emissions (carbon footprint), water, waste, non-renewable resources and biodiversity. The state of these across the New Zealand kiwifruit sector were then assessed over the ensuing years to manage the associated risks and opportunities.

More recently, the kiwifruit industry has increased its focus on sustainability. Retailers require increasing transparency of the growing systems, inputs, environmental measures, and labour practices that sit behind the product on their shelves – both to protect their own reputations and to position themselves against competitors. As the industry adopts sustainable business practices that earn the trust of consumers and communities, the value of the Zespri brand will strengthen as well as enable the continued growth of our industry.

Zespri has developed a framework for sustainability, setting out their priorities under the three pillars of:

Our Kiwifruit - promote healthy eating and lifestyles, actively encouraging people to eat better and live healthier.

Our Environment - striving to address how production, supply and sales impact on and enhance the environment with a focus on packaging, water quality and climate change.

Our Communities - making a positive contribution to peoples' livelihoods and wellbeing, through the returns provided to growers, the working conditions provided for our people, and the contributions we make in our markets.

4.3 OUR KIWIFRUIT

Health and Wellbeing Benefits of Kiwifruit

Nutrient Density

Right:
Comparison of the nutrient adequacy and nutrient density properties of Zespri kiwifruit and other commonly eaten fruit

	NUTRIENT ADEQUACY
KIWIFRUIT, ZESPRI SunGold	14.2
LONGAN	12.8
AVOCADO	10.8
KIWIFRUIT, ZESPRI GREEN	8.7
DURIAN	8.5
MELON (CANTALOUPE)	7.0
ORANGE	6.8
MANDARINS	6.7
POMEGRANATES	6.2
PEARS	4.1
MANGO	4.0
BANANAS	3.7
PINEAPPLE	3.7
CHERRIES	3.4
CRANBERRIES	3.1
STRAWBERRIES	3.1
TOMATO	2.7
WATERMELON	2.7
BLUEBERRIES	2.6
GRAPES	2.5
APPLES	1.9
PAPAYA	1.9

	NUTRIENT DENSITY
KIWIFRUIT, ZESPRI SunGold	22.5
LONGAN	21.3
MELON (CANTALOUPE)	20.6
TOMATO	14.9
ORANGES	14.4
KIWIFRUIT, ZESPRI GREEN	14.3
MANDARINS	12.7
STRAWBERRIES	9.7
WATERMELON	8.9
POMEGRANATES	7.4
PINEAPPLE	7.3
PEARS	7.2
CRANBERRIES	6.8
MANGO	6.7
DURIAN	5.8
AVOCADO	5.4
CHERRIES	5.4
BLUEBERRIES	4.5
PAPAYA	4.4
BANANAS	4.2
APPLES	3.6
GRAPES	3.6

Nutrient adequacy is a measure of how many nutrients the fruit provides relative to its weight. The calculation factors the nutrient composition of each fruit as a percentage of the of the Recommended Daily Allowance (RDA) for 16 specific vitamins and minerals, including protein, fibre, calcium, iron, vitamin A, thiamin B1, riboflavin B2, niacin B3, vitamin B6, vitamin B12, folate, vitamin C, vitamin D, vitamin E, pantothenic acid B5, and magnesium.

Nutrient density measures how many nutrients the fruit provides relative to the number of calories it contains i.e., the nutrient adequacy score is divided by the number of calories the fruit has. The high amount of vitamin C in kiwifruit is the primary driver of its high nutrient adequacy score. Other nutrients boosting this score include fibre, folate, and vitamin E. Kiwifruit's high nutrient density is one of the key advantages it has over other commonly eaten fruit.

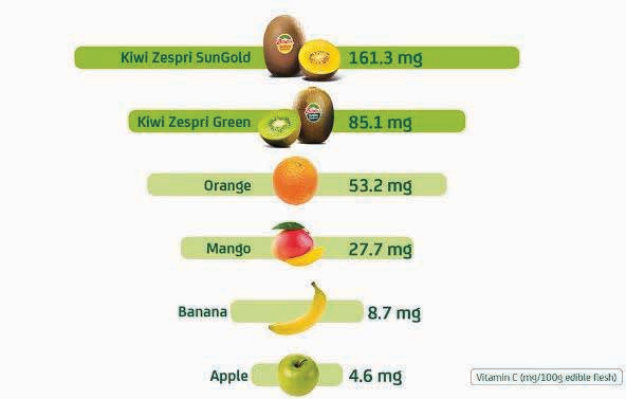
Vitamin C

Vitamin C plays a significant role in maintaining good health by influencing various components of the immune system and promoting a general feeling of vitality. Vitamin C helps to activate a number of enzymes in your body that improve metabolic energy levels and different neurochemicals in the brain.

Humans can only obtain vitamin C through their diet, and because the body can only store a limited amount vitamin C needs to be ingested daily. Various fruits and vegetables are rich in vitamin C, and kiwifruit is one of the best sources of vitamin C among fruit and vegetables.

Kiwifruit is high in vitamin C which helps strengthen the body's natural defenses

Right:
Vitamin C content comparison graph



Dietary Fibre

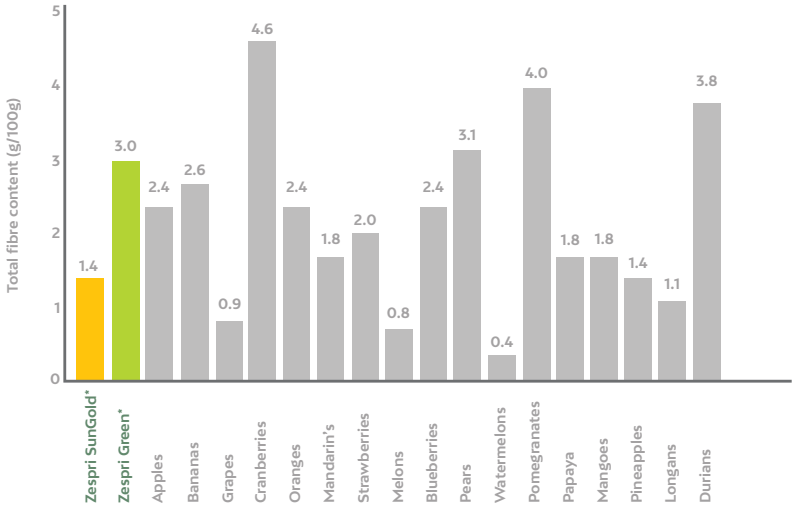
Dietary fibre is made up of plant components that reach the intestine without being digested and undergo total or partial fermentation in the large bowel by gut bacteria. Dietary fibre has been linked with a multitude of health benefits including digestive health, the regulation of glucose in the blood, blood cholesterol levels and weight management.

There are two types of fibre, both necessary for good health:

- **Soluble fibre** (pectin, gums and mucilage) found mainly in plant cells: Helps to lower blood cholesterol levels and can help to reduce constipation. Found in fruits, vegetables, oat bran, barley, flaxseeds, dried beans, lentils, peas and soy products.
- **Insoluble fibre** (cellulose, hemicellulose and lignin) from the structural part of plant cells: The main effect of insoluble fibre is to add bulk of faeces, and to alleviate constipation and associated problems such as haemorrhoids. It is also linked to reduced cardio-vascular risk. Found in wheat bran, corn bran and rice bran, the skins of fruits and vegetables, nuts, seeds, legumes and wholegrain cereals.

Kiwifruit contains both soluble and insoluble fibre at a ratio of approximately 1:4 in Green Kiwifruit and 1:3 in SunGold. Pectic polysaccharides (the soluble fibre in kiwifruit) have the ability to retain water and form gels, which supports digestive comfort.

Right:
Fibre content comparison graph



* USDA Nutrient Database 2012 (Release 28) ** New Zealand FOODfiles 2014 Version 01

Folate

Folate (vitamin B9) is an essential nutrient for cell growth and development and is important in the formation of the red blood cells which transport oxygen, iron and other minerals. Women need significantly higher levels of folate before and during pregnancy. It is vital for normal fetal development e.g., for reducing the incidence of neural tube defects. Folate is so important for healthy body functioning that many countries fortify bread and flour with folic acid (synthetic form) to ensure more of their population, particularly women, have an adequate dietary intake. However, between 50 to 80% of folate is destroyed if cooked, so kiwifruit that are generally eaten raw are an excellent source.

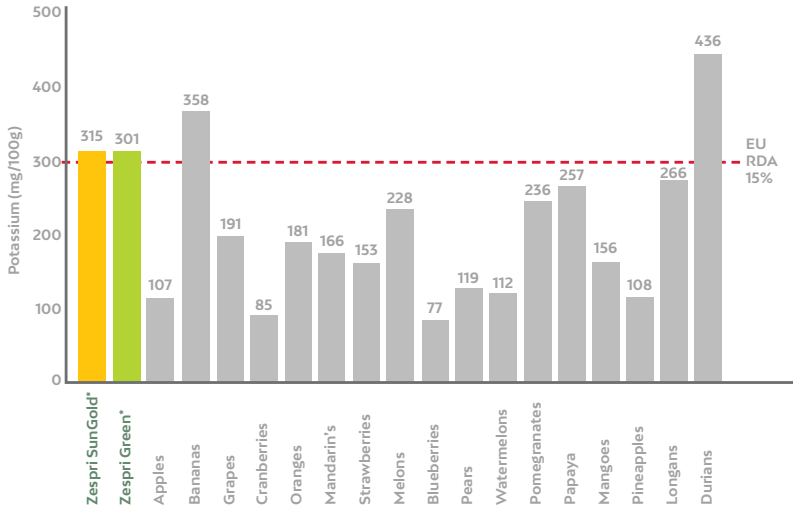
Below:
Folate content comparison table

	MEASURE	DIETARY FOLATE	US RDA*	US RDA	EU PRI*	EU RDA	NZ RDI*	NZ RDI
	g	µg	µg	%	µg	%	µg	%
AVOCADO	100	110.0	400	27.50	330	33.33	400	27.50
MANGO	100	43.0	400	10.75	330	13.03	400	10.75
KIWIFRUIT, ZESPRI GREEN	100	38.0	400	9.50	330	11.52	400	9.50
POMEGRANATES	100	38.0	400	9.50	330	11.52	400	9.50
PAPAYA	100	37.0	400	9.25	330	11.21	400	9.25
DURIAN	100	36.0	400	9.00	330	10.91	400	9.00
MANDARINS	100	34.0	400	8.50	330	10.30	400	8.50
KIWIFRUIT, ZESPRI GOLD	100	31.0	400	7.75	330	9.39	400	7.75
ORANGES	100	27.0	400	6.75	330	8.18	400	6.75
STRAWBERRIES	100	20.0	400	5.00	330	6.06	400	5.00
MELON (CANTALOUPE)	100	19.0	400	4.75	330	5.76	400	4.75
BLUEBERRIES	100	12.0	400	3.00	330	3.64	400	3.00
PEARS	100	7.0	400	1.75	330	2.12	400	1.75
CHERRIES	100	6.0	400	1.50	330	1.82	400	1.50
PINEAPPLES	100	5.0	400	1.25	330	1.52	400	1.25
TOMATO	100	2.6	400	0.65	330	0.79	400	0.65
GRAPES	100	2.0	400	0.50	330	0.61	400	0.50
CRANBERRIES	100	1.0	400	0.25	330	0.30	400	0.25
APPLES	100	0.0	400	0.00	330	0.00	400	0.00
BANANAS	100	0.0	400	0.00	330	0.00	400	0.00
WATERMELON	100	0.0	400	0.00	330	0.00	400	0.00
LONGAN	100	N/A	400	N/A	330	N/A	400	N/A

Potassium

Potassium is an important mineral for the normal function of the nervous system and muscular contraction. It is also beneficial in maintaining normal blood pressure and heart health. Potassium maintains fluid and electrolyte balance. Food processing tends to lower potassium levels and increase sodium levels (with associated negative impacts on health). Whole, fresh foods such as fruits, green vegetables and cereals or wholemeal bread are generally higher in potassium and lower in sodium. Kiwifruit is a great natural source of potassium, almost comparable to bananas – the fruit traditionally linked with potassium.

Right:
Potassium content comparison graph



* USDA Nutrient Database 2012 (Release 28) ** New Zealand FOODfiles 2014 Version 01

Actinidin

Uniquely, Kiwifruit contains actinidin, a highly active cysteine protease enzyme. This enzyme can break down a wide range of food proteins more completely and faster than the body's digestive enzymes can do on their own. Actinidin may also play a role in maintaining muscle health as enhanced food protein digestion in the small intestine improves protein absorption, which is linked to muscle repair. It has been observed that the presence of actinidin causes a more rapid emptying of the stomach when digesting beef. This means that eating kiwifruit with a protein-rich meal can offer benefits for people with a compromised digestive system and help reduce the sensation of heaviness and the gastric disturbances typical of protein-rich diets.

Levels of actinidin in kiwifruit differ between varieties although the methods of testing and reporting differ so comparison is difficult. Generally, Green kiwifruit contain the highest amounts of actinidin, with lesser amount in Gold varieties and virtually none in Red. Actinidin levels may also be a function of maturity of the fruit.

Kiwifruit, Actinidin and food allergies

Actinidin may be responsible for a small number of people who report allergic reactions to kiwifruit. Those that have mild allergies to Green Kiwifruit do not typically have the same reaction to SunGold but should consult a healthcare professional before trialling it.

Antioxidants

Antioxidants, found in certain foods, scavenge and neutralise free radicals from the body's cells and prevent or reduce the cell damage caused by oxidation. These include the nutrient antioxidants vitamins A, C and E and a range of biologically active phytochemicals. Vitamin E and the polyphenols and flavonoids found in both Green and SunGold are the major contributors to the antioxidant capacity of kiwifruit. Quercetin, a flavonoid in kiwifruit, has both antioxidant and anti-inflammatory properties. Carotenoids lutein and zeaxanthin also support antioxidant function in the body, particularly in eye health. Gold kiwifruit is particularly high in the polyphenol epicatechin, and Green kiwifruit has a range including epicatechin, lutein and kaempferol. While it is not possible to link the polyphenolic compounds in kiwifruit to any specific health benefit, strong evidence exists demonstrating that eating foods with polyphenolic compounds contributes to good overall health. 30% of the total polyphenols in SunGold are found in the skin, so plan to eat them with the skin on.

Glycaemic Index

The Glycaemic Index (GI) is a relative ranking of carbohydrates in foods according to how they affect blood glucose levels. Different foods are classified as High, Medium or Low on the Glycaemic Index.

- High GI **>70**
- Medium GI **55-70**
- Low GI **<55**

High GI foods are rapidly digested and absorbed, and result in a rapid, marked rise in plasma glucose levels, whereas the same amount of carbohydrate in low GI foods are more slowly digested and absorbed, resulting in a gradual rise in plasma glucose response and insulin levels. Management of blood sugar levels is particularly important for people with Pre-diabetes and Diabetes, a growing portion of the population.

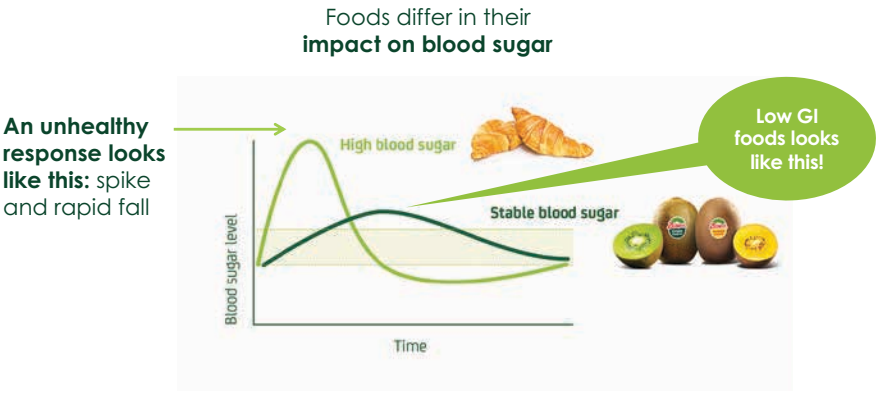
Right:
Glycaemic Index table

	Serving Size	Glycaemic Index	Glycaemic Index Rank
	9	Glucose comparison - 10g CHO	L.M.H
Avocado	100	15	L
Tomato	100	15	L
Kiwifruit, Zespri SunGold	100	38	L
Apples	120	39	L
Kiwifruit, Zespri Green	120	39	L
Strawberries	120	40	L
Oranges	120	43	L
Bananas	120	47	L
Mandarins	120	47	L
Durian	100	49	L
Mango	120	51	L
Blueberries	100	53	L
Papaya	120	56	M
Grapes	120	59	M
Pineapple	120	59	M
Cherries	120	63	M
Melon (Cantaloupe)	120	70	H
Watermelon	120	76	H
Cranberries	100	n/a	n/a
Longan	100	n/a	n/a
Pears	100	n/a	n/a
Pomegranates	100	n/a	n/a

> There is growing evidence highlighting that consuming of kiwifruit has a positive impact on the microbiota in the colon which have also recently been identified as a new potential factor in obesity-related disorders.

Approximately 80% of the dry weight of ripe kiwifruit consists of available carbohydrates, including glucose, fructose and sucrose at a ratio of about 2:2:1. The remaining 20% of the dry weight of kiwifruit consists of protein (10%) and fibre (10%).

Right:
How foods affect your blood sugar



Of these sugars, glucose has a GI of 100% (the benchmark), fructose 19% and sucrose 68%. With a low GI of 38-39, combined with a modest content of carbohydrate, and a fibre component that slows the rate of absorption, kiwifruit is an excellent fruit choice for people with diabetes trying to manage their blood sugar levels.

There is growing evidence highlighting that consuming of kiwifruit has a positive impact on the microbiota in the colon which have also recently been identified as a new potential factor in obesity-related disorders. Growing evidence in clinical studies suggests that alterations in the colonic microbiota of people with obesity may lead to chronic low-level inflammation, insulin resistance and onset of Type 2 diabetes.

4.4 OUR ENVIRONMENT

4.4.1 Packaging

Like many other products, kiwifruit is exported around the world in packaging designed to protect it and ensure the best quality fruit is delivered to consumers. In recent years, images of damage to wildlife caused by plastic have put a spotlight firmly on plastics in supply chains. In recognition of this concern and to meet increasing customer requirements for less plastic, in 2019, Zespri signed up to a New Plastics Economy Global Commitment to have packaging that is 100% reusable, recyclable, or compostable by 2025.

See: https://ellenmacarthurfoundation.org/topics/plastics/overview

Further, Zespri is striving to ensure that any plastic packaging used will be made from at least 30% recyclable plastic by 2025, and that they will reduce the packaging carbon footprint, per kg of fruit, by 25% by 2030. Their definition of packaging includes both transport packaging and consumer packaging. Significant pieces of research are underway to achieve these goals related to better understanding the current packaging used and it's impacts, and to find alternative materials or solutions that will allow the continued delivery of high-quality fruit to consumers. In 2022, Zespri are measuring at 87% against their target of 100% recyclable, reusable or compostable packaging across all markets.

See: https://www.zespri.com/en-NZ/Sustainability-Our-Environment

This work also includes finding more sustainable alternatives for fruit labels. All export markets require individual fruit labelling. The labels not only provide an important means of differentiating Zespri fruit varieties but offer an assurance to customers that the fruit they are purchasing is authentic, safe and high-quality Zespri Kiwifruit. An example of this ongoing workstream includes the introduction of home compostable paper fruit labels on conventional fruit in France this year.

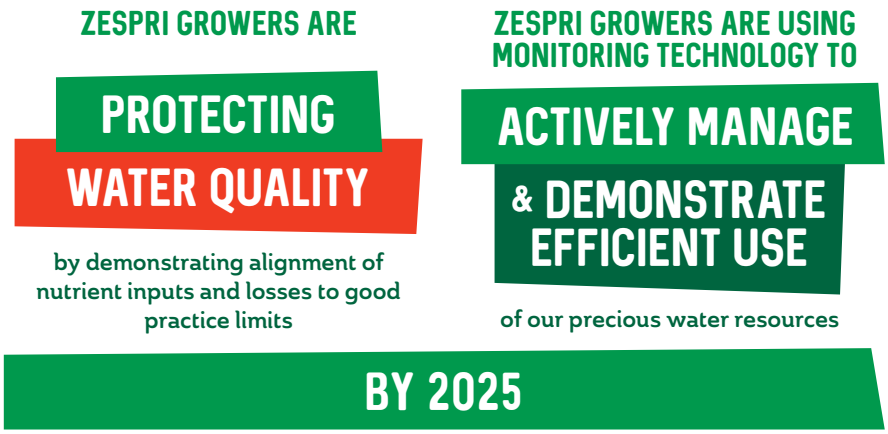
4.4.2 Water

Declining freshwater quality and availability has become a global concern. Although by world standards, New Zealand has clean and abundant freshwater, the quality in some of New Zealand's rural and urban areas has come under increased pressure due to land-use intensification and the loss of nutrients (e.g., urine and fertilisers) from farms into waterways..

Industry Water Strategy

In 2019, He Wai mō Āpōpō /Water for the Future - A Water Strategy for the Kiwifruit Industry, was released. This strategy was created with input from NZKGI, Zespri, Māori Kiwifruit Growers, Horticulture NZ and growers. The Water Strategy aims to collectively protect and enhance our water resources for our people, our environment and our communities while enabling kiwifruit industry growth. This includes looking at how the kiwifruit industry uses water, how we can do so in the most sustainable way and how we can gather data to measure our progress and improve. The focus of the working groups that support this strategy is on nutrient management, efficient water use and improving soil health.

The strategy can be found on NZKGI website: https://www.nzkgi.org.nz/wpcontent/uploads/2020/09/J002013_Water_Strategy_Document_Update_R2_ Final_WEB_Small.pdf



National Water Policy – Essential Freshwater

The government is focused on improving water quality around New Zealand and making sure that people only use what they need. To ensure that this happens, the government has developed Essential Freshwater Policy which has a number of regulatory measures, which include:

1. **National Policy Statement for Freshwater Management 2020 (NPS-FM)**
   The clearing of native vegetation, New Zealand's growing population, urbanisation, farming/forestry, the drainage of wetlands and the damming and modification of rivers and streams have all had significant effects on our land and placed increasing pressure on our water bodies and ecosystems. In response to this, and to protect freshwater quality, the New Zealand Government established the NPS-FM in 2014 which was amended in 2017 and renewed in 2020. The NPS-FM directs regional councils, in consultation with their communities, to set objectives for the state of freshwater bodies in their regions and to set limits on resource use to meet these objectives.

Regional Councils are currently implementing the NPS-FM via regional plans and are required to notify plans no later than 31 December 2024. The NPS-FM can be found on the Ministry for the Environment website:

See: https://environment.govt.nz/publications/national-policy-statement-for-freshwater-management-2020/

2. National Environmental Standards for Freshwater (NES-F)

A new national standard was released in 2020 and provides specific direction on water use, in particular where rapid action is required, for example, in at-risk catchments. It requires landowners to protect wetlands and streams on their land, record and report water usage, and ultimately to have a Freshwater Farm Plan. These plans will identify clear outcomes or goals to be met in relation to ecosystem health and farm practices that respond to environmental needs, amongst others. The industry has submitted that these requirements can be met through an environmental module in the ZespriGAP audit (see Chapter 8 for more on ZespriGAP)

The new rules can be found on the Ministry for the Environment website: https://environment.govt.nz/publications/action-for-healthy-waterways-information-for-horticultural-growers/

For more on water policy and Freshwater Farm Plans see: https://www.nzkgi.org.nz/what-we-do/environmental-and-policy/water/

3. Resource Management Act (RMA)

A review of the RMA was completed in 2020, undertaken in recognition that the Act was no longer considered fit for purpose. The specific aim of the review was to improve environmental outcomes and better enable urban and other development within environmental limits. In Feb 2021, the Government announced it would repeal the RMA and replace it with three new Acts:

- Natural and Built Environments Act (NBA), to protect and restore the environment while better enabling development, as the primary replacement for the RMA
- Strategic Planning Act (SPA), to help coordinate and integrate decisions made under relevant legislation by requiring the development of long-term regional spatial strategies (RSSs)
- Climate Adaptation Act (CAA), to address complex issues associated with managed retreat and funding and financing adaptation.

For more on these changes see: https://environment.govt.nz/publications/our-future-resource-management-system-materials-for-discussion/

4.4.3 Climate Change

The Earth's climate is warming, which will lead to more weather variability and extremes as the average temperatures rise. Zespri has reported on the climate-related risks to the kiwifruit industry.

They used a scenario-based approach as is recommended by the Task Force on Climate related Financial Disclosure (TCFD), Intergovernmental Panel on Climate Change (IPCC) and International Standards Organisation.

The two scenarios considered:

- Moderate (2°C) Emissions scenario – where aggressive action keeps global warming to within 2°C i.e., a world that has succeeded in implementing the Paris Agreement and is likely to keep total warming below a 2°C tipping-point
- High (4°C) Emissions scenario – where global warming continues unchecked i.e., a world where countries have failed to meet their emissions reduction pledges under the Paris Agreement.

Climate Variable	Potential Impact	Projected change in 2050		Risk Rating
		2°C scenario	4°C scenario	
Average temperatures	Rising average temperatures may increase the risk of pests and pathogens becoming established in primary growing regions.	**~0.9°C**	**~1.1°C**	**High**
Minimum temperatures	A rise in minimum spring temperature may prevent consistent bud-break and king flower production in primary growing regions.	**~1°C**	**~1.25°C**	**High**
Maximum temperatures	A rise in summer maximum temperatures may increase energy costs in postharvest sorting and distribution centres.	**~1°C**		**Moderate**
Number of hot days (>25°C)	An increase in the number of hot days in primary growing regions may increase the risk of heat stress among orchard workers.	**~75%** increase	**~95%** increase	**Moderate**
Average Rainfall	Kiwifruit vine water demand may increase with rising temperatures, impeding on fruit development in water-deprived areas.	Substantial regional and seasonal variation.		**Moderate**
Drought	An increase in the severity and frequency of droughts, especially in already dry areas, may impede on fruit development.	**100mm** increase in PED[3]		**Moderate**
Number of dry days (<1mm / day rainfall)	An increase in the number of dry days may marginally alter the risk of drought and water stress in primary growing areas.	**0-5%** Increase in dry days		**Low**
Extreme rainfall events	An increase in extreme rainfall events may marginally alter the risk of harvest losses, soil erosion, flood damage and diminish soil productivity.	**0-5%** increase in the magnitude of a 99th percentile rainfall event		**Low**
Extreme wind speeds	An increase in extreme wind speeds may see more wind damaged fruit on the vine.	**0-2.5%** increase in the magnitude of a 99th percentile daily mean wind speed		**Low**

Figure 1: Zespri physical climate risk scenario analysis and risk ratings for New Zealand growing regions. (PED = Potential Evapotranspiration Deficit)

Risk Ratings	
High	May require adaptive action in the short to medium term in order to minimise negative financial impacts.
Moderate	May require adaptive action, but uncertainties are high/ timescales long. Keep a watching brief.
Low	Little clear evidence of risk requiring adaptive action. Revisit when fresh information becomes available.

Figure 2: Risk ratings applied to assess Zespri's New Zealand climate-related risks

Temperature change

A rise in minimum spring temperatures is likely to have a greater impact on the Hayward variety, which requires more chilling. Rising average summer temperatures will increase vine water demand and may impede fruit development in water-deprived areas. An increase in the number of hot days could cause thermal stress and have negative impacts on production. Warmer temperatures are expected to lengthen growing seasons. Plants will start maturing earlier potentially exposing them to frosts. Although the number of frosts is generally expected to decline, when they do occur, their impact could be much larger than previously experienced. Frost protection will become increasingly important. Biosecurity risks are expected to increase with invasive pests and pathogens finding conditions more suitable as the climate warms.

On the flip side, warmer temperatures and longer growing seasons in some regions may result in higher quality fruit (e.g., increased dry matter) and yield. Warmer temperatures may make existing sites with sub-optimal growing conditions (colder) more favourable and alternative growing locations may become more suited to production.

Rainfall

There is less certainty about changes in rainfall because it is more difficult to model. It is changes in rainfall patterns that are more likely to impact than reduction in rainfall. Enhanced risk of dry periods and drought are considered likely and may be intensified by increasingly strict water use regulations. Under a High emissions scenario, water access is likely to become a key concern over a long-term period (30-80 years). Heavier rainfall events are expected, which could have impacts such as flooding and waterlogging of soils.

Hail

In New Zealand growing regions there is a projected decrease in precipitation (including hail) over time. However, crop damage due to large hail events has been experienced in recent times (Motueka, December 26, 2020) and remains a risk, one potentially affecting not just the current crop but future crops.

Wind & other extreme weather events

Changes in wind speed are unlikely to be severe before mid-century. However, risk of wind-rub damage may rise and should be monitored so that additional protective measures can be put in place as appropriate. There is an expectation that the frequency with which extra-tropical cyclones may impact on kiwifruit growing regions in New Zealand will increase. However, current climate change models display little uniformity in their projection of intensity, frequency or reach of these storms in coming decades.

Non-Physical Risk

Climate change does not only pose physical risks to the kiwifruit industry. The risk of tightening environmental regulations and increasing consumer concerns about unsustainable products are likely to impact more in the short to medium term (10-30 years), where the physical risks will steadily increase over a longer time frame.

The Paris Climate Change Agreement, ratified in 2016 and now signed by 194 countries around the world, set a target of limiting total global warming to 1.5°C. Over time this will likely result in increased costs for Zespri. For example, markets including the US, EU and UK are currently exploring the introduction of carbon border tax adjustments. International agreements to reduce emissions from shipping are also expected to increase international distribution costs. In New Zealand, cost increases will be imposed through changes to the Emissions Trading Scheme (ETS) and National Policy Statement on Freshwater Management (NPSFM).

As European and North American customers, in particular, increasingly choose products based on the carbon footprint and other environmental impacts of the producing organisation, this may have brand impacts for Zespri if aspects such as carbon emissions are not well managed.

Industry Response

Adapting to the physical impacts of climate change can be assessed on different levels:

- **Tactical adaptation:** This involves modifying production practices within the current system, such as using different sprays, irrigation practices, pest management strategies, or pruning practices.
- **Strategic adaptation:** A change is made to the current production system in a substantive way which may mean a change in cultivar, a change to the vine support trellising system, or the installation of netting for hail protection or shade. Zespri's assessment of new varieties in the industry's cultivar development programme considers traits related to climate change, such as greater pest and disease resistance and no reliance on bud-break enhancers.
- **Transformational adaptation:** Involves adoption of a new production system, or a change in the location of the industry. Climate change could see kiwifruit being grown in parts of New Zealand where it currently isn't because of the climate in those areas becoming more favourable for kiwifruit. Other factors like soil and water availability would need to be favourable too to support this.

see more on the horticulture industry adapting to climate change: https://www.mpi.govt.nz/dmsdocument/26788/direct

Zespri is investing more than $1 million per year in research to understand more about mitigating and managing the impacts of climate change. From assessing the carbon footprint of the Zespri Global Supply business, to understanding the water requirements of kiwifruit vines, investigating soil carbon storage, and modelling the impact of changes in weather on yield, there is commitment to taking a science-led approach to the solutions that are put in place.

Right:
Hail damage to fruit and canes, Motueka 2020.

4.5 OUR COMMUNITIES

In 2021/22 Zespri donated more than 130 tonnes of fresh and healthy kiwifruit to those most in need in New Zealand, partnering with food rescue organisations and other community partners. Zespri supports charities which share their values and commitments, such as KidsCan. This year, their partnership delivered fruit to schools as well as new, warm rain jackets to those at KidsCan's partner schools. Zespri also supported two recent 24-hour KidsCan dollar match campaigns which raised over $30,000, while another 25 people also signed up to become regular monthly supporters for the first time – a significant outcome as it means an additional 35 children will now have access to KidsCan's programmes.

Beginning in 2020, Zespri partners with the Young and Healthy Charitable Trust to support the 'Zespri Young and Healthy Virtual Adventure' programme, aimed at encouraging primary-aged children and their families to eat better, be more active, and more environmentally conscious. This online programme involves a 5-week adventure where the 20,000 participants build their own avatar and learn in fun and engaging ways healthy behaviours like drinking more water, eating nutritious food and fewer treats, and getting better sleep, in order to help them lead healthier lives. The programme is supported by ASICS ambassadors Ameliaranne Ekenasio, Ardie Savea, Kane Williamson, and Samantha Charlton. Students gain points through engaging in healthy behaviours in real time to move around a global course, virtually visiting countries like Japan, China and more. As part of the adventure, over 250 pairs of ASICS running shoes were delivered to participating classes to support their efforts.

See: https://www.youngandhealthy.org.nz/

Zespri became the new naming rights partner of flagship sporting tournament the AIMS Games. The event is one of the largest sporting championships in the Southern Hemisphere, and saw more than 25,000 officials, supporters and intermediate-aged athletes descend on the Bay of Plenty in September, for the first time since 2020. Zespri's Head of Global Public Affairs Michael Fox says Zespri AIMS Games is a fantastic celebration of youth sport and a landmark event for Tauranga. "We firmly believe that as we grow, so too must our contribution to our communities, and supporting the AIMS Games was a fantastic way in which we could say thanks to our local community. We also see this as an important investment in the skills, leadership and wellbeing of our next generation." "There was no shortage of volunteers to assist with the event and that says a lot about our industry, but also the enthusiasm for the event in the Bay of Plenty."

Right:
Katikati Primary School Students at the launch of the Zespri Young & Healthy Virtual Adventure at their school

Far right:
Just one of the 23 sports represented in the Zespri AIMS games

4.6 SCIENCE

Organic Production

There is increasing consumer desire for healthy, nutritious, safe and good tasting foods that are also good for the environment. As the world's population becomes more conscious of their consumption, they are increasingly willing to pay a premium for healthy products. "The organic market is the fastest expanding, multi-food category globally, pushing double digit global growth over the last decade and is now mainstream. The world wants safe, clean, honest food." (2018 OANZ Report)

In 2022, there are 438 hectares of organic green kiwifruit and 222 hectares of organic gold kiwifruit in production. Organically grown kiwifruit generally has lower average yields than conventionally grown kiwifruit. This is offset by a premium price achieved over that for conventional fruit. It is therefore possible for the returns of organic growers to be as good if not better than conventional growers. The core markets for Zespri Organic are North America, Europe and Japan which account for over 80% of Zespri Organic sales by volume (2018 OANZ Report).

Zespri Organic Kiwifruit is grown to the strictest organic standards and is certified by Bio-Gro, New Zealand's organic protocol organisation. Key input differences are that fewer agrichemicals can be used on organic orchards and synthetic nitrogen (e.g., CAN, urea) is not permitted.

Regenerative Horticulture (RegenHort)

Regenerative Agriculture (RA) is a concept focussed on reducing the impacts of food production on our environment while remaining profitable. This considers a range of positive practices including rotational grazing, cover cropping, increasing biodiversity, wetland restoration, fencing setback from waterways, riparian planting, and low-till cultivation.

With funding from the Ministry for Primary Industries' (MPI) Sustainable Food and Fibres Futures Fund, Zespri has partnered with T&G Global and Plant & Food Research on a project to research, develop, define, and promote sustainable and regenerative horticulture practices within the kiwifruit, apple and berry industries (RegenHort). This is one of 11 research projects across the country making up MPI's programme Regenerating Aotearoa.

See: https://www.mpi.govt.nz/dmsdocument/52975-Regenerating-Aotearoa-Investigating-the-impacts-of-regenerative-farming-practices

The first year of RegenHort is currently underway and focused on conducting scientific research on what is known about regenerative practices. At the same time, market analysis will be undertaken to understand consumer perceptions and drivers.

The drivers for the program were identified through industry consultation:

1. Improved environmental outcomes
2. Enhanced orchard productivity / profitability
3. Enhanced market performance
4. Enhanced social licence to operate
5. Meet regulatory requirements

Based on the work to date, the following goals for RegenHort are proposed:

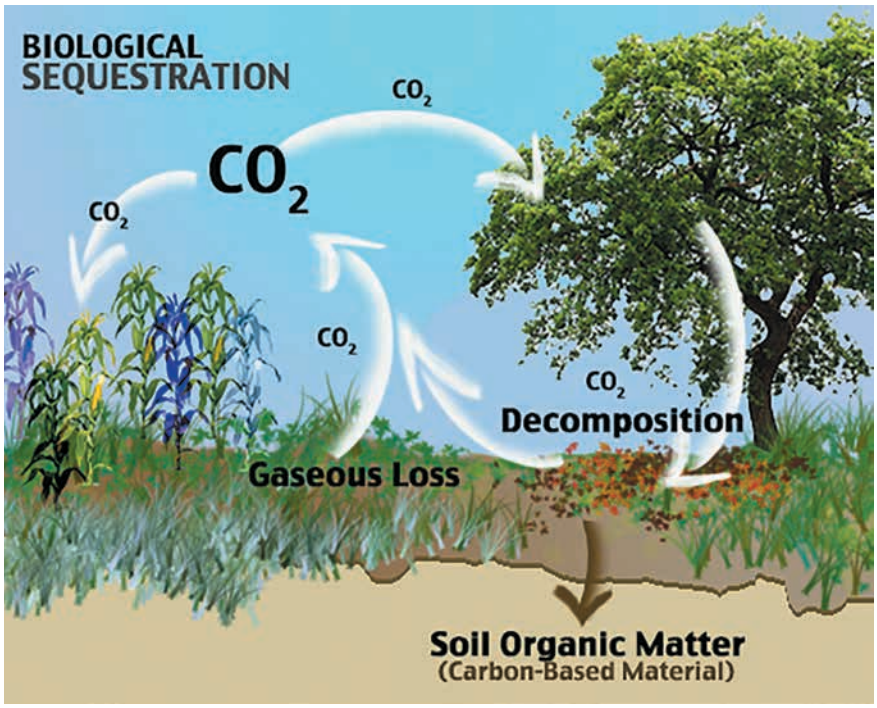
- **Land / Whenua** - healthy soil and resilient landscapes
- **Climate / Ahuarangi** - low carbon and climate-resilient production
- **Biodiversity / Koiora** - nature and taonga species thrive across our productive landscapes
- **Water / Wai** - Waterways are protected and thrive
- **Social / cultural** - livelihoods in our Industry are enhanced

Many of the management activities growers are using could be termed regenerative, and it is hoped that the RegenHort project will identify these and more and so grow the evidence base for the application of regenerative farming practices.

Carbon Sequestration

This is the process by which carbon dioxide is absorbed during photosynthesis, and is stored as carbon in biomass (trunks, branches, foliage, and roots) and in the soil (Image below). Kiwifruit orchards therefore have the potential to sequester carbon in vines plus shelterbelts ("Biomass") and ultimately in the soil in the form of organic matter. This could go some way to offsetting emissions associated with producing the fruit. Research is underway to understand the amount of carbon being sequestered in NZ kiwifruit orchards.

Right:
Biological sequestration



> "Kiwifruit orchards therefore have the potential to sequester carbon in vines plus shelterbelts ("Biomass") and ultimately in the soil in the form of organic matter."

The Role of Soil

For many growers, the health and quality of their soils is an important consideration in their management activities. Globally, health and quality of soils is also seen as important by consumers, retail customers and society. Reasons for this include the role of soil in supporting food production, filtering of water, supporting ecosystem biodiversity and function in the carbon cycle.

Storage of carbon in kiwifruit soils as organic matter occurs because of how we grow and manage our orchards. Many Bay of Plenty orchards are located on allophanic soils that, due to their chemical properties, are good at stabilising any organic carbon deposited within the soil profile. Kiwifruit vines have a root system that can explore soils at depth, and typically can turnover about 40 percent of their root mass annually. For soil carbon accumulation, this root turnover has two main benefits:

- it can deposit carbon from the roots not remobilised into the plant
- the channels created by roots that have died back can provide earthworms with deeper access into the soil profile.

Pergola-trained kiwifruit vines also maintain a moist soil surface over summer, allowing surface organic matter to be broken down by soil microorganisms, and digested by earthworms or washed into root channels for deeper deposition.

Once deposited, this organic matter can improve water storage capacity of soils; reducing the amount of irrigation required or in some cases the need for irrigation. Soil organic matter also plays an important role in reducing the leaching of nutrients, such as nitrogen, and subsequently improving the efficiency of their use, as well as supporting microorganisms that assist in remobilising nutrients from soils for plants. As some food cultivation systems can result in the degradation of organic soil matter and soil function, it is important to be able to demonstrate to our customers the long-term sustainability of our soil resources.

To read more on Soil Organic Carbon (SOC) in Kiwifruit Orchards See: http://www.biosoil.co.nz/vdb/document/18

4.6.1 Sustainable Nutrient Management

When the term 'sustainable nutrient management' is used, it is often in relation to maintaining or improving freshwater quality. The most prevalent problem is eutrophication which is the nutrient enrichment of freshwater bodies leading to the growth of unwanted aquatic plants like algae and rooted plants. Excessive levels of nutrients in water can also be harmful to animals and humans, particularly infants.

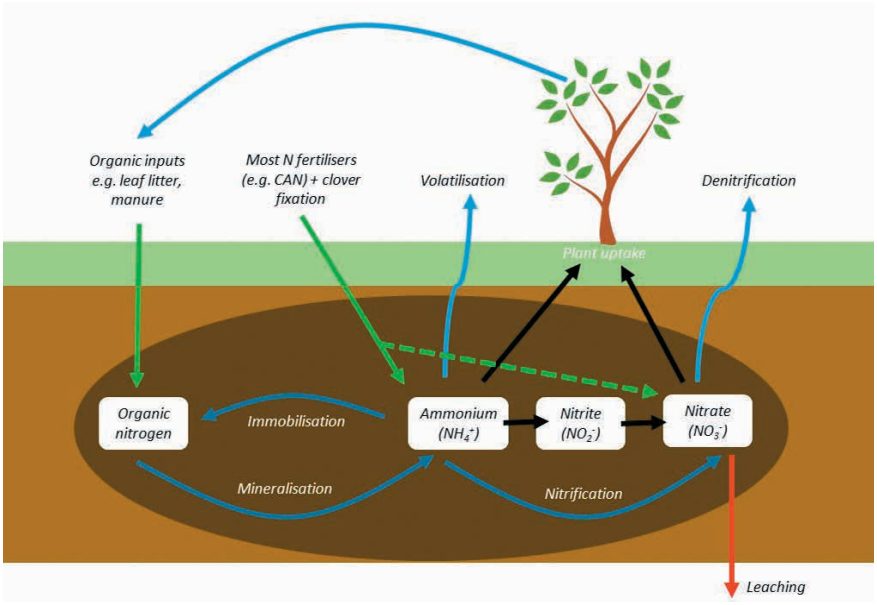
Nitrogen (N) and Phosphorus (P) are presently the main nutrients of concern and must be carefully managed as the input of these into a water body can significantly affect its quality. Consequently, there is growing social and regulatory pressure to mitigate the impacts of these. Understanding the N and P cycles, and how these can move from land and into water bodies is key to managing these nutrients effectively. Losses of sediment and E. coli to freshwater are also a concern in some places.

Leaching

Leaching refers to the loss of nutrients and other chemicals through the soil with water as it drains through. Weather (particularly rainfall), soil characteristics, irrigation, fertiliser practices and plant uptake are the main factors that contribute to leaching from kiwifruit orchards. An orchard with a free draining soil that is saturated, where soluble fertiliser is applied prior to a major drainage event (e.g., heavy downpour) may lose a significant amount of nutrients.

Nitrogen (N) is the main leaching risk for freshwater quality. This is because nitrogen applied to or already present in the soil is converted to nitrates (NO3-), which are not strongly held by the soil and are therefore are readily leached with water as it drains down through the soil profile. Although N is usually available in the soil for plant uptake initially in the form of ammonium, which leaches much less, this is converted to nitrate through the microbial process of nitrification (see figure below).

Right:
Soil nitrogen cycle for a plant-based system



How Much N is applied to Kiwifruit Orchards and How Much is Leached?

Generally, mature kiwifruit orchards generally receive around 100 kg N/ha/yr (Nitrogen/per hectare/per year), give or take about 20%. Developing orchards may receive more to develop canopy quickly. On conventional orchards, more soluble fertilisers like calcium ammonium nitrate (CAN; 27% N) are commonly applied while on organic orchards, relatively insoluble inputs like composts are often used, at 5-10 tonnes/ha; developing orchards and orchards where soil organic matter is low may receive considerably more compost than this.

The associated N losses to water from kiwifruit orchards has previously been modelled to be typically less than 20kg NO_3-N/ha/yr on average (for orchards in the Bay of Plenty where most orchards are located) . However, the model (OVERSEER™) used for this has not been well calibrated for kiwifruit so there is some uncertainty around the accuracy of these values. Research is therefore underway to better understand losses from orchards. In this, nitrogen losses are being directly measured using drainage fluxmeters.

As far as ecological and human health concerns are framed, it's the concentration of nitrate-nitrogen (mg N/L, or parts per million) in water that is important, not the loading (kg N/ha/yr). High concentrations of nitrate in drinking water can pose a health risk for certain people, particularly bottle-fed babies who drink formula made with the water. For this reason, the Ministry of Health has a Maximum Acceptable Level (MAV) of 11.3 mg/L (or parts per million) for nitrate-nitrogen. Measured and modelled values for kiwifruit on average have been found to be below this.

How are Nutrient Losses Determined?

Directly measuring nutrient losses from farms is not practical and is expensive. Therefore, models are often used to estimate losses. In kiwifruit, two models called OVERSEER™ and SPASMO have been used previously as these have dedicated kiwifruit components. OVERSEER™ is the most widely used model in New Zealand agriculture and is being used to develop nutrient budgets i.e., reports showing the amounts of nutrients added and lost from farms. In some places it is mandatory for OVERSEER™ to be used in order to obtain consent to farm. Overseer is not used much in the kiwifruit industry, one of the reasons being that it has not yet been well calibrated for kiwifruit and should therefore be used with caution.

For more information, visit http://overseer.org.nz.

Phosphorus

Phosphorus is the other main nutrient of concern for freshwater quality. Like N, too much P in aquatic environments can lead to excessive plant growth, algal blooms and the depletion of oxygen dissolved in the water. But unlike N, the main pathway for P entering our waterways is via run-off, unless the soils are coarse pumice or sandy in which case leaching could occur. Generally, P losses from kiwifruit orchards are thought to be low because orchards are relatively flat and so surface run-off of water is lower. Also, features like grass swards and shelterbelts impede run off. Research is underway to measure P run-off from kiwifruit orchards.

Recommended Practices for Sustainable Nutrient Management in Kiwifruit

The 4Rs of Nutrient Stewardship

This is the concept of applying the right fertiliser source at the right rate at the right times in the right place. More specifically:

- Fertiliser inputs should match what the plant requires taking into account production goals as well as the availability of nutrients in the soil. The process of mineralisation (i.e., release of N from organic matter) should be considered as this can supply nitrogen for plants. Applying higher amounts of N may not necessarily increase production but result in unwanted vigour.
- Don't apply N when the drainage risk is high, for example in the wetter winter months and when the soil is waterlogged.
- If N is applied in one application, then some of that will not be taken up by the plant and be available in the soil to be leached. First application of the season should be as close to bud break as practical. Applying well before in wetter months does not advantage N uptake but increases the risk of leaching. Generally, for kiwifruit it is recommended to split applications i.e., apply around two thirds prior to budbreak and the rest in late spring/ early summer, prior to fruitset.

Other options for minimising nutrient losses in a kiwifruit orchard are presented below. Growers should consider how these might affect their economic and production objectives.

Plant Vegetation Around Waterways

Buffer zones of vegetation adjacent to waterways act as a last line of defence and will filter nutrients as well as reduce erosion and enhance biodiversity. These zones are commonly referred to as riparian zones.

Minimise Bare Ground

Plants present in orchards will take up nutrients that would otherwise be lost. Ground cover also protects the soil which is beneficial. Research is proposed to better understand the benefits of ground covers in kiwifruit orchards where low light conditions are a challenge to establishment, as are other practices such as agrichemical use. Having a sward with clover present instead of bare ground is beneficial as it will add N to the orchard system because the clover assimilates N from the atmosphere (through the process of nitrogen fixation).

Sustainable Management Practices: How does your region measure up?

For the regions where kiwifruit is mostly grown, freshwater quality is generally stable or improving although some individual measures in some regions have been deteriorating. To view freshwater quality trends for a specific region or catchment, visit the Land Air Water Aotearoa (LAWA) website http://www.lawa.org.nz.

Maintain Plant Health

Ensuring good plant health and healthy root systems will help to prevent leaching by ensuring the plants are functioning optimally to take up nitrogen.

Consider Less Soluble Forms of N

Organic fertilisers for example are thought to be inherently less soluble and N leaching risk is less. However, they may not deliver sufficient available nutrients to meet fruit production goals. Less soluble forms of synthetic fertiliser (e.g., slow or controlled release) are also available, however like organic forms they may not supply sufficient nutrient when required and are usually more expensive.

4.6.2 Agrichemcial Use

Agrichemical use is required to achieve desirable production outcomes; however, agrichemicals usually have environmental and human health risks associated with their use. Zespri and the kiwifruit industry are committed to mitigating these risks and have the following processes in place to do so:

1. Zespri operates a good agricultural practice assurance programmed called ZespriGAP (based on GLOBALG.A.P.) which growers must comply with. This has a significant number of requirements that growers must meet relating to the use of agrichemicals. (For more information on GLOBALG.A.P see section 8.3)
2. Zespri each year produces a Crop Protection Standard which prescribes in detail what agrichemicals can be used on kiwifruit, when and how much.
3. Related to the above, the industry operates a "KiwiGreen" programme in which orchards are monitored for pests and if only one of the thresholds are reached can sprays be applied. This helps to minimise sprays use on orchards.
4. Those applying agrichemicals must be trained i.e. GROWSAFE approved (https://www.growsafe.co.nz/).
5. All agrichemicals used must be recorded in an online spray dairy provided by Zespri, which is audited.
6. At harvest, Zespri tests fruit for agrichemical residues to ensure fruit is free of harmful residues.
7. Zespri are investing in Research & Development to identify safer agrichemicals.

Copper Case Study

Copper, which has been commonly used in kiwifruit to control the Psa disease and to encourage natural leaf drop, is presented as a case study to illustrate the impacts associated with agrichemicals. The case study is split into three parts: a description of copper and what it is used for; copper's ecological impacts; and copper's impact on the health of kiwifruit plants.

What is Copper Used for?

Copper is registered for use on virtually all food/feed crops as a form of disease control. Copper sprays are used in many horticultural industries to protect foliage and fruit from a range of bacterial diseases. Copper is also used by some kiwifruit growers as a defoliant in autumn i.e., to accelerate leaf drop.

Successful disease control depends on both an even distribution, and good retention of the copper across all plant surfaces. Copper is most effective on those diseases that need water present to develop—such as Psa.

Copper is a bactericide, and it can kill the bacteria on contact. The copper ions travel through the cell walls of the bacteria and disrupt the cellular enzyme activity. It is non-systemic i.e., it is not absorbed or circulated by a plant; it only kills bacteria on the plant surface. As copper is a protectant, it needs to be applied evenly to the plant surface before the disease develops. It is often applied in conjunction with adjuvants that have super spreading capabilities, to allow better coverage with a lower total dose of copper.

Ecological Impacts

Small quantities of copper are necessary for the functioning of most forms of life, but to most aquatic organisms excess levels of copper are highly toxic. The main cause of copper toxicity to fish and aquatic invertebrates is through rapid binding of copper to the gill membranes, which causes damage and interferes with osmoregulatory processes. The amount of cupric ion in the environment, and its toxicity to aquatic animals through gill damage, is dependent on a number of water quality parameters including pH, alkalinity, and dissolved organic carbon.

Many terrestrial animals have the ability to cope with some amount of excess copper exposure by storing it in the liver and bone marrow. Laboratory toxicity studies have shown that exposure to high levels of copper in the diet can overwhelm the ability of birds and mammals to maintain the stability of their body's internal environment in response to changes in external conditions. However, animals which are repeatedly exposed to levels of copper (which do not cause permanent harm) may undergo enzymatic adaptation which allows them to cope with greater levels of exposure. Available data from a honeybee acute toxicity study indicated that copper is practically nontoxic to honeybees.

To reduce ecological exposures, product use labels have been amended, by way of a reduction of application rates, defining application intervals, and determining seasonal maximum application rates. Monitoring weather conditions and minimising spray drift go some way to reducing non-desirable impacts.

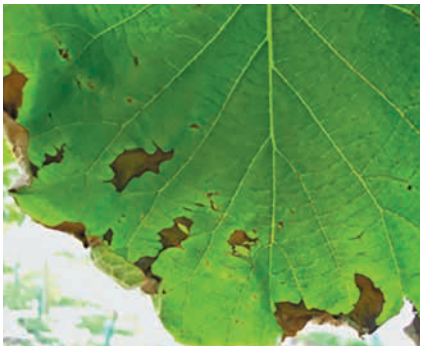
Plant Impacts

Copper (Cu) is considered as a micronutrient for plants. Enhanced industrial and mining activities have contributed to the increasing occurrence of Cu in ecosystems. Excess copper in the soil can induces stress and causes toxicity in plants. This leads to plant growth retardation and leaf chlorosis and/or burning. In kiwifruit vines copper toxicity often appears first in the leaves, similar to many other nutrient toxicities. Some key factors that play a role in toxicity problems are listed below:

- Using products that are not designed as agrichemicals
- Excessive chemical rates
- Tank mixing of multiple chemicals
- Poor tank agitation
- Slow drying conditions
- High temperatures during application
- An excessive use of spreader/super-spreaders at high water rates
- An excessive build-up of chemicals on leaves

Right:
Leaf speckling

Far right:
Leaf burn at the leaf margin



Right:
Bronzing of the upper leaf surface

Far right:
Brown staining of leaf veins

Growers must weigh up the risk of disease killing their vines, the risk of chemical use to the environment, and the risk of phytotoxicity resulting in small, light green leaves that cannot support the development of high yielding high quality fruit.

Zespri works closely with growers to ensure that copper, a critically necessary tool to manage Psa, is used effectively with minimum environmental impact. An upper limit is placed on the amount of copper that a grower can apply in one year and this is closely monitored by Zespri – 8 kg/ha/yr for conventional and 6 kg/ha/yr for organic.

4.7 BIOSECURITY

As an island nation, New Zealand has a unique ecosystem as our native species evolved without any natural predators. The arrival of new species, including humans, has disrupted the balance many times. The introduction of pests and diseases remains a continual threat to our economy, environment, and way of life.

Biosecurity in New Zealand is not a single line of defence at the border, rather it is a multi-layer system that begins offshore (including international and trade agreements and treatment offshore), incorporates the border interventions, and continues post-border. Here it becomes a joint effort with action and measures taken by central and local government, industries, the science community and others. These post-border activities include surveillance for early detection of new pest incursions; readiness and response actions when a new pest is detected; and on-going pest management to contain or reduce the impact of pests that have become established.

Kiwifruit Vine Health (KVH)

KVH is a leading biosecurity organisation, dedicated to supporting the New Zealand Kiwifruit Industry. They were established in December 2010 to lead the industry response to the Psa incursion. Since November 2012, KVH has been the lead organisation responsible for managing all biosecurity readiness, response, and operations on behalf of the industry. KVH works collaboratively with kiwifruit growers, NZKGI, Zespri, the postharvest and associated industries such as beekeepers, pollen providers, nurseries and contractors, and Government, particularly the Ministry for Primary Industries (MPI).

Investment in Science to understand the nature of significant biosecurity threats, and developing tools for their management should they arrive, is a big priority for the industry. KVH and Zespri have already invested over $16 million in Psa research and innovation to understand how to manage the disease and are looking to invest more in research for other biosecurity threats.

See: https://kvh.org.nz/

KIWIFRUIT'S MOST UNWANTED

Kiwifruit Vine Health (KVH) undertakes readiness and response planning to minimise the impact of future biosecurity incursions to the kiwifruit industry.

The following organisms are considered the highest risk to the kiwifruit industry, based on the likelihood of them getting here and establishing; and the potential production and market access implications should this occur.

Our next incursion won't necessarily be an organism on this list however. We all need to be on alert for any unusual pests or plant symptoms and maintain on-orchard biosecurity best practice ALL the time.

FRUIT FLIES

Queensland, Oriental, Mediterranean

- High likelihood of entry – have crossed our borders many times.
- Production impacts for a range of horticultural crops, but considered low for kiwifruit.
- Severe market access restrictions, particularly for Queensland Fruit Fly which is not present in most major kiwifruit markets.

Risk Months: Sep – June
I can enter NZ hiding on:

BRAZILIAN WILT

Ceratocystis fimbriata

- Soil-borne pathogen causing damage to kiwifruit in Brazil – reports of up to 50% vine loss.
- Vine death can occur extremely rapidly after expression of symptoms. Hayward on Bruno rootstock also affected.
- No known effective treatments.
- May be eradicable with good biosecurity practices and if detected early.

Risk Months: Year Round
I can enter NZ hiding on:

BROWN MARMORATED STINK BUG

- Pierces kiwifruit resulting in fruit drop and rot. Fruit loss is typically 5-10% but up to 30% on worst blocks.
- Extremely difficult to eradicate – early detection is essential.
- Major nuisance pest overwintering inside houses in huge numbers.
- High likelihood of entry as a hitchhiker on shipping containers, cars, machinery and luggage.

Risk Months: Sep – Apr
I can enter NZ on:

SPOTTED LANTERNFLY

- Attacks over 70 host species, including kiwifruit - eradication efforts overseas have been unsuccessful.
- Production impacts from extensive feeding resulting in oozing wounds, wilting, and sooty mould growth, which can be prolific.
- Hitchhiker pest that is hard to control – tends to fly out of ochards when sprayed and return later.

Risk Months: Sep – May
Look out for my eggs on:

PSA NON NZ STRAINS

- NZ has one form of Psa – others exist internationally and could cause severe impacts if they get here.
- Psa in Japan and Korea appears to be more virulent to Hayward than the NZ form of Psa.
- New Psa strains could be more virulent to 'Psa tolerant' cultivars.
- May be difficult to distinguish from "common" Psa so best practice is not to spread any form.

Risk Months: Year Round
I can enter NZ hiding on:

WHITE PEACH SCALE

- Regularly intercepted on imported fruit. Therefore no imported fruit should be taken on to orchards as a precaution.
- Up to 20% production losses reported on Italian orchards.
- NZ envrionment considered favourable for establishment.

Risk Months: Nov – Mar
I can enter NZ hiding on:

VERTICILLIUM WILT

- In susceptible kiwifruit cultivars infection always leads to plant death, which occurs suddenly.
- Many strains worldwide – only Chile has reported a strain virulent against kiwifruit.
- Good biosecurity hygiene practices are essential to manage spread of this soil-borne pathogen.

Risk Months: Year Round
I can enter NZ hiding on:

INVASIVE PHYTOPHTHORAS

- Known as the plant killers – a group of significant plant pathogens and a major threat to all plant sectors.
- Species have caused significant impacts to kiwifruit offshore. Many other known and unknown species could also cause impacts under certain conditions.
- Easily spread, particularly with plant material movements.
- Can spread in plants showing no symptoms.

Risk Months: Year Round
I can enter NZ hiding on:

For more information about these organisms and other biosecurity threats to the kiwifruit industry, see the fact sheets on the KVH website at **www.kvh.org.nz**

CATCH IT SNAP IT REPORT IT

TO REPORT UNUSUAL PESTS OR DISEASES

CALL THE MPI HOTLINE 0800 80 99 66 OR KVH 0800 665 825

4.7.1 Case Study: Exotic Fruit Flies

There are three species of fruit fly of particular concern: the Oriental Fruit Fly (*Bactrocera dorsalis*), the Mediterranean Fruit Fly (*Ceratitis capitate*) and the Queensland Fruit Fly (*Bactocera tryoni*).

These fruit flies are considered one of the most serious biosecurity threats to the kiwifruit industry due to their ability to cause serious damage to crops, as well as their economic consequences – which would be far greater and include market access implications as well as costs associated with quarantine and monitoring.

Queensland Fruit Fly (QFF) are of particular concern as this species has a very limited distribution in Australia, but the highest risk of entry to New Zealand given our proximity, trade and tourism routes.

New Zealand is one of the only countries in the world that has a major horticultural industry and is free of fruit flies that attack commercial fruit. This is of significant advantage to our growers exporting to other markets and is something that New Zealand works hard to maintain. Our fruit fly surveillance programme has been operating for almost 20 years and involves over 7800 traps nationwide for post-border detections.

Fruit flies are most likely to arrive in fresh produce brought into New Zealand commercially or privately with passenger arrivals. There have been many border detections, as well as some significant post-border detections that have triggered biosecurity responses:

- A breeding population of Mediterranean Fruit fly was found in Auckland in 1995.
- A Queensland Fruit Fly breeding population was found in Auckland in 2015, and multiple flies were discovered in 2019, although no breeding population was detected.

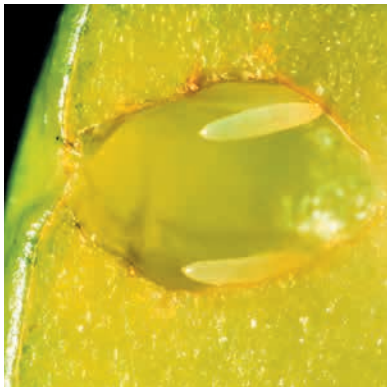
The high-risk period for fruit fly incursions is September to June. KVH data shows there were 110,000 trap inspections during the 2021/22 season, with 7,000 samples from the traps sent for testing, all thankfully negative.

Identification

Not to be confused with the tiny drosophila or vinegar flies often found around decaying fruit, these fruit flies are a similar size to the common house fly. Adult QFF are 6-8mm, reddish-brown with distinct yellow markings. However, since the most likely entry for QFF to New Zealand will be in infested fruit or vegetables, it is important to be able to identify eggs and larvae in fruit.

Right:
Adult Queensland Fruit Fly

Far right:
QFF eggs in an apple



Signs and Symptoms

The adult female QFF has a sharp retractable ovipositor (egg-laying organ) at the tip of her abdomen. She uses this to dig a flask-shaped chamber around 3mm deep in the outer layer of the fruit, where she then deposits up to 12 eggs. These eggs hatch after 2-3 days, the larvae (maggots) then begin feeding on the inside of the fruit.

Clues that fruit is infested with QFF:

- a sting on the surface of the fruit — you might also see a sting (about the size of the top of a pin) on the surface of the fruit where the adult female QFF lay the eggs
- eggs inside host fruits and vegetables — eggs are white, 1mm long and banana-shaped. They can be hard to see.
- maggots (larva) inside fruit — maggots are 5mm to 10mm long and creamy-white in colour. They usually eat towards the centre of the fruit and cause it to rot (though the fruit might look in good condition from the outside).

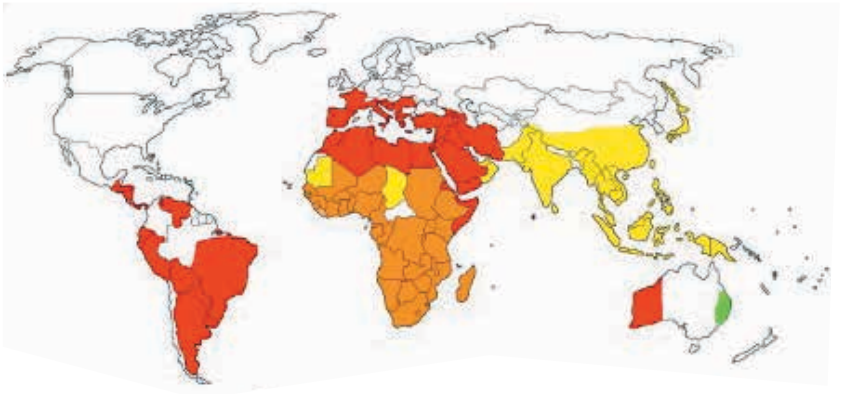
Right:
QFF maggot and sting in tomato

Distribution and Climate Range

Oriental and Mediterranean Fruit Fly are both widely distributed over the world, with many host species recorded. QFF is endemic to Australia and found only in the Eastern states. In its native home, QFF costs growers hundreds of millions of dollars in damage and pest control. Millions more are spent on control measures to prevent further spread within Australia and are lost in access to international markets. QFF has already spread beyond Australia to New Caledonia, French Polynesia and Pitcairn Island. Conditions in New Zealand are somewhat favourable for a population of QFF to establish should they avoid detection at the border, but only in the northern regions. However, this may change as the climate warms. Incursions of QFF could result in the greatest impact from markets since this pest is not currently present in any of our major kiwifruit trading markets.

Right:
Map showing fruit fly distribution.

- Oriental Fruit Fly
- Mediterranean Fruit Fly
- QFF
- Mediterranean/Oriental Fruit Fly



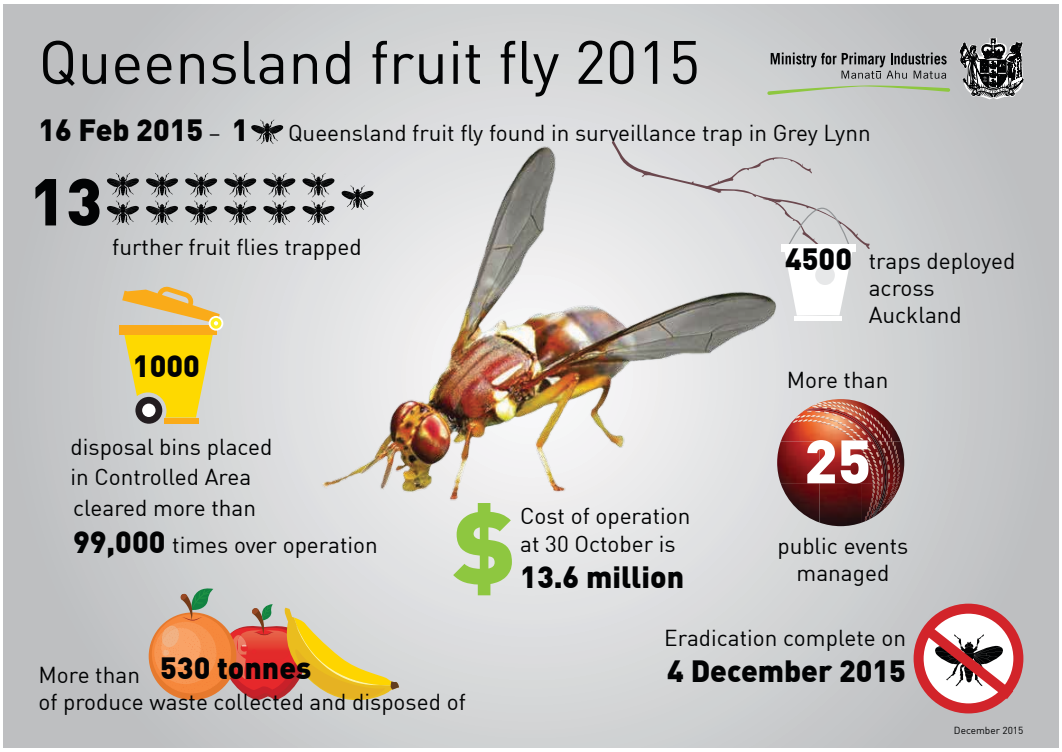
Control

Preventing entry, followed by early detection and immediate responses to any incursion are essential to preventing exotic fruit flies from establishing here. New Zealand deploys resources at the border to prevent entry including:

- Promotion to incoming passengers of the need to declare and dispose of fresh produce
- Detector dogs targeting fruit being carried by passengers
- Inspection of import consignments
- Accreditation scheme for cruise vessels to manage the risk of fresh produce on board
- Biosecurity screening of mail items

Beyond the border, there is a comprehensive surveillance network of almost 8000 pheromone traps. These target the three main fruit fly species but can detect over 80 species. The traps are checked every two weeks and placed in grids throughout New Zealand, including in kiwifruit-growing regions. There is an escalating sequence of prescribed response activities that take place once a fly has been detected.

This begins with an immediate STOP notice for the area to prohibit any fruit movement for 48 hours while control areas are established. Further surveillance traps are added, and fruit monitoring for larvae begins. If any evidence of a breeding population is found (eggs, larvae, mated female fly) further movement restrictions are put in place, potentially including an Export Restriction Zone (ERZ), while organism management begins (tracing, baiting, ground and cover spraying, and fruit collection). The MPI infographic below records the response to the 2015 QFF incursion, which occurred in an urban area (Grey Lynn, Auckland), not a fruit-producing area.



For more information see the Kiwifruit Growers' Fruit Fly Preparedness document at https://kvh.org.nz

4.7.2 Industry Response to Psa

***Pseudomonas Syringae* pv. *Actinidiae*, (Psa or Psa-V)**

Psa is a bacterial disease that can kill kiwifruit vines. It carries no risks associated with human or animal health and does not affect plants other than kiwifruit vines. It was discovered for the first time in New Zealand on a Te Puke kiwifruit orchard in November 2010. Since then, Psa has spread rapidly and now 93% of New Zealand's kiwifruit hectares are on an orchard identified with the disease.

Psa can spread rapidly through weather events, namely wind and rain, and the movement of plant material. It can also spread through unclean footwear, vehicles, machinery, and orchard tools. Psa thrives in wet, humid conditions; and multiplies quickly in wet conditions. Therefore, spring and autumn are high-risk periods for Psa to spread. The disease slows down in warm, dry conditions like summer.

In an orchard Psa can exist as:

- An epiphyte, living on plant surfaces without causing high levels of infection; and/or
- As an endophyte, living within the vine, having entered through natural plant openings or man-made wounds—resulting in severe infection.

Growth of the bacteria outside/inside the vines can result in leaf spotting, cane/leader dieback and, in extreme cases, vine death accompanied by the production of exudates.

Right:
Leaf spotting symptom of Psa (KVH)

Far right:
Exudate (ooze) coming from a kiwifruit plant is another symptom of Psa (KVH)

The outbreak of Psa in 2010 was a severe blow to the kiwifruit industry. The industry was seriously questioning its future as the vine killing disease rapidly spread and growers watched helplessly as entire orchards were removed. The greatest impact from Psa was felt in 2013/14 when grower payments were down 17 percent due to a 55 percent reduction in volumes of Gold kiwifruit. However, the focus of conversation about Psa among industry and government bodies nationwide today is more about the industry's remarkable recovery from it, rather than its grim history.

The success of the industry's recovery has been a combination of many factors but is underpinned by the replacement of the highly susceptible Hort16A variety, with the more Psa-tolerant Gold3 variety. Through a combination of research and development, grower innovation, and by banding together to share knowledge, an enormous amount of information has been discovered about the disease and how best to manage it.

Growers now have several tools and best-practice techniques available to them to help manage the disease and remain profitable in a Psa environment. This section will outline some of the initiatives and actions put in place by industry to bring the industry back from the brink of devastation and onwards to new levels of success.

Innovation - the Development of Psa Tolerant Cultivars

Plant & Food Research is the sole research provider to the New Zealand Kiwifruit Research Consortium, jointly funded by the Ministry of Business, Innovation and Employment (MBIE) and Zespri. Together they are developing new cultivars of superior quality that command a market premium, with a focus on taste, novelty and convenience. Additionally, new cultivars are bred with tolerance to diseases, including Psa.

In 2021, Zespri and Plant & Food Research launched a 50:50 joint venture named the Kiwifruit Breeding Centre. The Centre will be based in Te Puke, with a focus on driving greater innovation within kiwifruit breeding, creating healthier, better-tasting and more sustainable varieties. The organisations will share royalties from any future commercialised new varieties.

See: https://www.plantandfood.com/en-nz/article/new-kiwifruit-breeding-centre-launches-to-boost-innovation

Research and Development Programme

KVH and Zespri Innovation run a global research and development (R&D) programme into Psa. The programme was established in early 2011 and has enlisted the best scientific minds globally to provide solutions for Psa. The Innovation team partners with around 20 global researchers to provide the best available expertise to the New Zealand kiwifruit industry. The programme includes product testing to identify, rigorously test and get permission from MPI to use suitable products to help manage and control the spread of Psa. To date, more than 300 products have been tested for efficacy against Psa.

See: https://www.kvh.org.nz/Psa_RD

National Psa Pest Management Plan (NPMP)

The NPMP was established in May 2013 to prevent the spread of Psa-V and minimise its impacts on kiwifruit production. Key elements of the plan involved movement controls, monitoring, reporting, incursion response and managing the disease, along with a continued focus on awareness, education and research. KVH review the Operational Plan for the NPMP on an annual basis and make changes as necessary to ensure the NPMP objectives continue to be met.

As time has moved on the situation has changed. The focus of the plan on preventing spread has changed, with only the South Island and Far North still Psa-V free. There is now more emphasis on new Psa-V biovars (strains) that have and will continue to arise, including strains resistant to current chemical control tools. New kiwifruit varieties need to be monitored for tolerance to Psa in orchard environments. KVH have established protocols for controlling the movement of risk items, which differ depending on the nature and level of risk these items pose.

See: https://www.kvh.org.nz/KVH_Protocols

Pathway Management Plan (PMP)

In 2022, the Pathway Management Plan was introduced and will replace the NPMP in 2023. Instead of focusing on a single pest (like Psa) the new PMP focuses on protection against the full range of biosecurity threats to our industry (including Psa) and provides for a consistent and more pragmatic approach to managing pathway risks such as young plants, budwood, pollen, orchard equipment and other items moved by people. The PMP will mean the industry can detect anything new quickly enough to stop its spread, limit impacts, and aim for eradication.

See: https://kvh.org.nz/protocols-movement-controls/pathway-management-plan

GIA (Government Industry Agreement)

The importance a collaborative, coordinated response to biosecurity incursions is one of the biggest lessons the kiwifruit industry learnt from the outbreak of Psa in 2010. Since then, there is a more engaged biosecurity relationship with government and increased capability to respond thanks to the formalising of the Government Industry Agreement for Biosecurity Readiness and Response (GIA) Deed (signed in 2014), and Operational Agreements (OA) for specific threats.

GIA commits the kiwifruit industry to work with government and other primary sector industries to improve readiness for future biosecurity events, and jointly respond to future outbreaks. What makes the GIA concept so important to the kiwifruit industry is that it enables industry and government to achieve better biosecurity outcomes through the work undertaken jointly. Because decision making, costs and responsibilities are shared, all partners can have the confidence that the best decisions are being made about managing biosecurity – there isn't just one group making the big calls.

GIA was put into action in 2019 when KVH and other horticultural industry groups worked in partnership with the Ministry for Primary Industries (MPI) to respond to detections of fruit flies in three Auckland suburbs. The responses set up in Otara, Northcote and Devonport ran well under the GIA partnership, following the pre-agreed operational plans established and tested in previous responses. By being involved in decision-making processes, KVH was able to ensure the interests of New Zealand's kiwifruit growers were represented fully. Between mid-February and mid-November 2019, the kiwifruit industry contributed 43 people and 540 staff days to the response, assisting in operational activities that included surveillance, fruit collection, baiting, and public awareness.

> "KVH and Zespri Innovation run a global research and development (R&D) programme into Psa. The programme was established in early 2011 and has enlisted the best scientific minds globally to provide solutions for Psa."