CHAPTER FOUR
SCIENCE AND SUSTAINABILITY

Over the past few years, the kiwifruit industry has vastly increased its focus on sustainability. Therefore, this chapter has been expanded in 2019 and divided into five sections to give a broad overview of science topics under the sustainability lens. Firstly, in chapters 4.1 and 4.2, the key drivers for sustainability and the industry's priorities are laid out. In chapters 4.3, 4.4 and 4.5, these key priorities are expanded to provide an extensive overview of sustainability including topical subjects such as biosecurity, climate change and water management.

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.

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.

Right:
Zespri Kiwifruit displayed in a supermarket in Europe

4.2 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. 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 supports livelihoods. 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 is developing a framework for sustainability, setting out their nine priorities under the three pillars of:

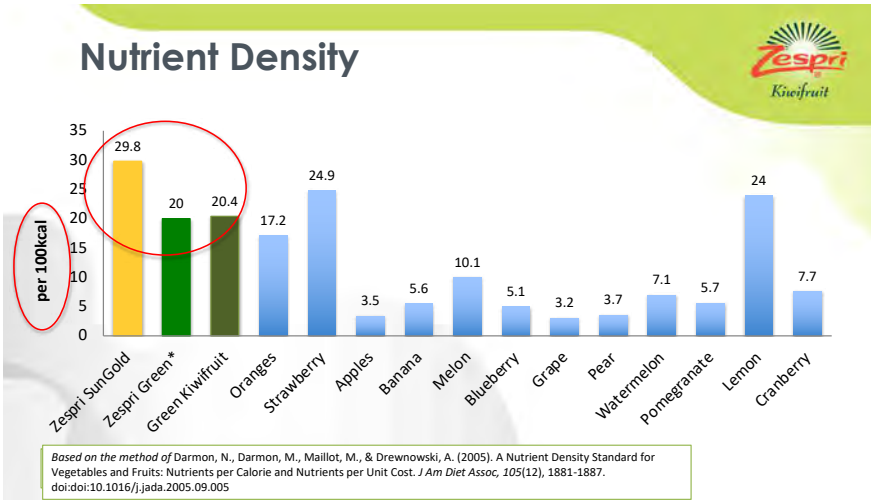
4.3 Our Kiwifruit - Helping people live healthier lives through great nutrition, supported by the highest standards of food safety.

4.4 Our Environment - Addressing how production, supply and sales impact on and enhance the environment, focusing on packaging, water quality and climate change.

4.5 Our Communities - Making a positive contribution to peoples' livelihoods and wellbeing, through delivering returns to growers, protecting our investment from new pests and diseases, good working conditions for our people and positive contributions in overseas markets.

4.3 OUR KIWIFRUIT

4.3.1 Health and Wellbeing Benefits of Kiwifruit



Right:
Nutrient adequacy score of kiwifruit

Actinidin

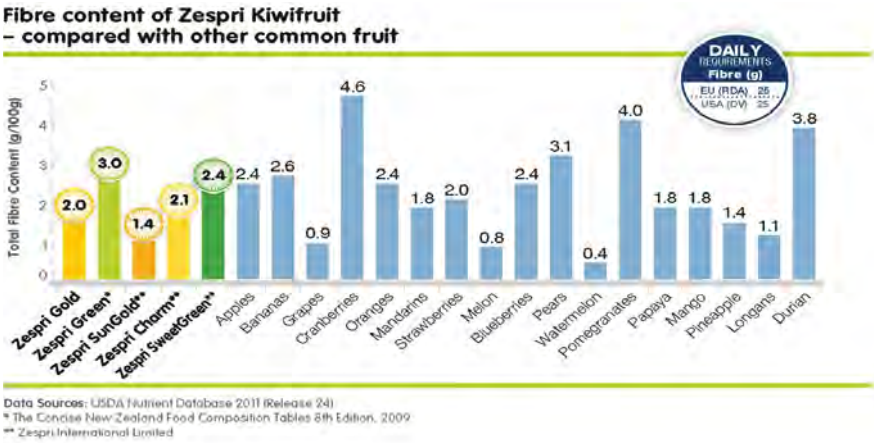
Kiwifruit contains actinidin, a highly-active proteolytic enzyme of the cysteine protease family, so called after the scientific name of the green kiwifruit vine, *Actinidia Deliciosa*. This enzyme has the ability to hydrolyse a wide range of food proteins more completely and faster than the digestive enzymes can do on their own. Recent in vitro and in vivo studies in rats and pigs have shown that eating green kiwifruit with a protein-rich meal improves the digestion of the proteins, particularly in the stomach. Actinidin can increase the absorption of proteins in the small intestine by improving the gastric digestion of proteins. 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.

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 benefits for digestive health, the regulation of glucose in the blood, and blood cholesterol levels. It also promotes the growth of beneficial bacteria in the colon and helps to control weight. Good quantities of fibre are found in wholegrain cereals, pulses, fruits and vegetables. There are two types of fibre, and both of them are necessary for good health:

- Soluble fibre (pectins and gums): Helps to lower blood cholesterol levels, and can help to reduce constipation. Found in fruits, vegetables, oat bran, barley, flax, seeds, dried beans, lentils, peas and soya milk.
- Insoluble fibre (cellulose, hemicellulose and lignin): The main effect of this type of fibre is to increase the bulk of the stools and to alleviate constipation and associated problems such as haemorrhoids. Found in the husks of wheat, maize and rice, the skins of fruits and vegetables, nuts, seeds, legumes and wholegrain cereals.

Right:
Fruit fibre content comparison graph

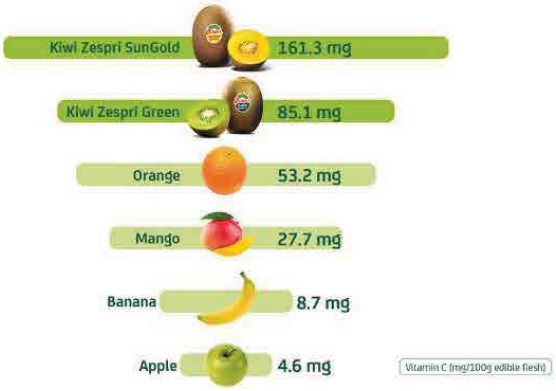


Vitamin C

Vitamin C is an essential vitamin for human nutrition. It plays a significant role in maintaining good health by influencing various components of the immune system, 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. This means taking more vitamin C could reduce the sensation of fatigue and increase physical and mental energy. The human body cannot synthesise vitamin C. This means that, in order to maintain good health and vitality, we must regularly eat foods that contain vitamin C. 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

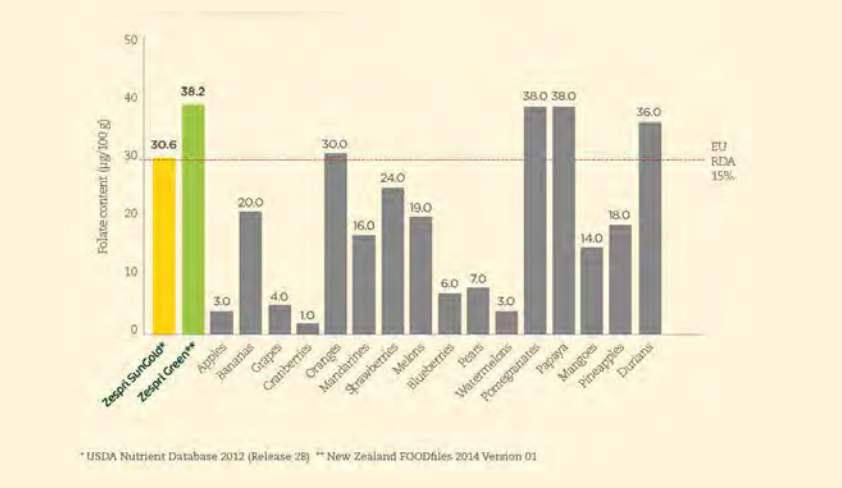
Right:
Vitamin C content comparison graph



Folate

Folate is an essential nutrient for cellular growth and development and is vital for the formation of the erythrocytes which transport oxygen, iron and other minerals. Folate performs important functions in the healthy body, and sufficiently high levels are needed before and during pregnancy. It is also vital for infant growth. Some of its functions include; growth of tissue during pregnancy, normal formation of amino acids, normal formation of blood cells, normal formation of homocysteine and normal psychological function.

Right:
Fruit folic acid content comparison graph



Potassium

Potassium is an important mineral for the development of many different body functions. In particular, it contributes to the normal function of the nervous system and is necessary for muscular contraction. Fresh foods such as fruits, green vegetables and cereals or wholemeal bread are generally high in potassium and low in sodium. Kiwifruit is a natural source of potassium.

Right:
Fruit potassium content comparison graph

Antioxidants

Antioxidants are found in certain foods and neutralise free radicals, helping to reduce the damage caused by oxidation. Despite the vitamin E levels are not that high in kiwifruit, Zespri Gold and SunGold contain a relatively high quantity of vitamin E compared to other fruit. Research has shown a significant increase in plasma antioxidant measures following the consumption of kiwifruit compared to the consumption of other fruit and foods. Kiwifruit contains a wide range of antioxidants, such as vitamin C and polyphenols. The polyphenols present in both Zespri Green and Zespri SunGold Kiwifruit also have an antioxidant effect.

Low Glycaemic Index

The Glycaemic Index (GI) indicates the amount of glucose that is released during digestion from carbohydrates into the blood system.

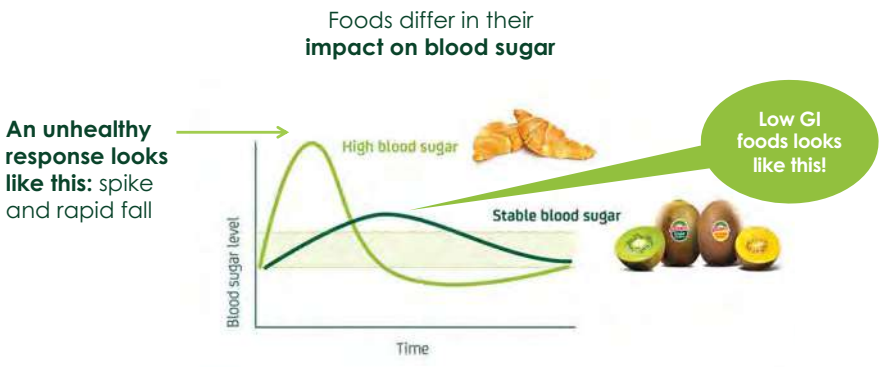
- High GI **>70**
- Medium GI **55-70**
- Low GI **<55**

The Glycemic Index (GI) for the three varieties of Zespri Kiwifruit is:

- Zespri Green: **39**
- Zespri Gold: **49**
- Zespri SunGold: **38**

The carbohydrates available in ripe kiwifruit are a mixture of glucose, fructose and sucrose in a proportion of 2:2:1. Of these sugars, glucose has a GI of 100% (the benchmark), fructose 19% and sucrose 68%. There are other factors capable of reducing the speed of absorption of glucose, i.e. the GI. In the case of kiwifruit, it has been observed that the impact it produces on plasma glucose levels is less than its Glycaemic Index – in other words very low. For this reason, kiwifruit is a healthy option for people with a reduced tolerance to glucose, for example people with diabetes.

Right:
How foods affect your blood sugar



4.4 OUR ENVIRONMENT

Organic Production

Consumers are becoming increasingly concerned about how their food is produced and the associated impacts of getting fruit to market. Some consumers look for options that are more environmentally friendly in particular organics and this is driving significant growth - "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 2017, about 165 orchards in New Zealand were growing organic kiwifruit representing about 480 hectares. Organically grown kiwifruit generally has lower average yields than conventionally grown kiwifruit, however this is offset by a premium over 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 global 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.

A study undertaken by The Agriculture Research Group on Sustainability (ARGOS) found that the environment of kiwifruit orchards is good regardless of whether they are organic or conventional, but that there are some differences between organic and conventional systems. For more information visit: www.argos.org.nz.

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 has 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://www.ellenmacarthurfoundation.org/our-work/activities/new-plastics-economy.

Significant pieces of research are underway to achieve this goal related to better understanding the current packaging used and it's impacts, and to find alternative materials or solutions that will allow the continued deliver of high-quality fruit to consumers.

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 been come under increased pressure due to land use intensification and the loss of nutrients (e.g. urine and fertilisers) from farms into waterways.

National Water Policy

The government is focussed 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**
   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 a National Policy Statement for Freshwater Management (NPSFM) in 2014 which was amended in 2017 and will be amended further in 2019. The NPSFM 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 NPSFM. Councils are required to implement the NPSFM in their policies and plans no later than 31 December 2025. Details of each regions implementation programme is available on the Ministry for the Environment website http://www.mfe.govt.nz/fresh-water/national-policy-statement/regional-councils-implementation-programmes.

2. **National Environmental Standard Freshwater**
   This is a new proposed national standard which is expected to be released in September 2019 and will likely provide specific direction on water use, in particular where rapid action is required, for example, in at-risk catchments.

3. **Review of the Resource Management Act (RMA)**
   The review of the RMA will be in two stages. The first stage will look at resource consenting, enforcement and Environment Court provisions through an amendment. The second stage will be a comprehensive review open which will require public consultation.

WATER FOOTPRINT

The water footprint is an indicator of freshwater use that looks at both direct and indirect water use of a consumer or producer. The water footprint of an individual, community or business is defined as the total volume of freshwater used to produce the goods and services consumed by the individual or community or produced by the business. Water use is measured in terms of water volumes consumed (evaporated or incorporated into a product) and/or polluted per unit of time. A water footprint can be calculated for a particular product, for any well-defined group of consumers (for example, an individual, family, village, city, province, state or nation) or producers (for example, a public organisation, private enterprise or economic sector). The water footprint is a geographically explicit indicator, showing not only volumes of water use and pollution, but also the locations (Source: http://www.waterfootprint.org).

In 2011, the water footprint for Zespri Green Kiwifruit was published. It was reported that 417L of water was used to produce a kg of fruit or 42L per piece of fruit. Most of this water was provided by rain.

For more information visit:

http://www.landcareresearch.co.nz/science/living/sustainable-business/carbon-footprinting/water-footprinting

http://www.scoop.co.nz/stories/BU1107/S00014/zespri-quantifies-kiwifruit-water-footprint.htm

https://www.zespri.com/companyinformation/newsroom/kiwifruit-water

http://www.radionz.co.nz/news/national/78946/single-kiwifruit-needs-42-litres-of-water,-study-shows

4.4.3 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.

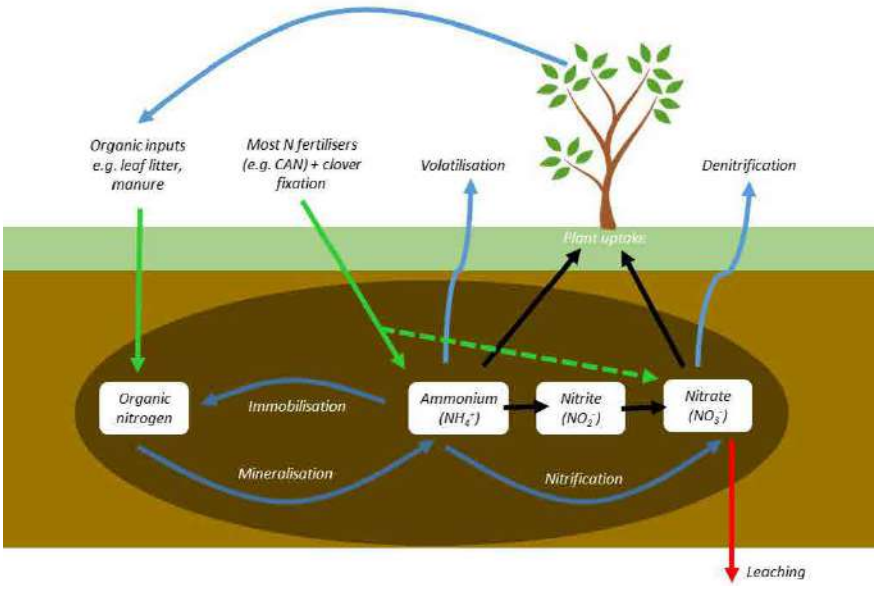
Nitrogen (N) and Phosphorus (P) are presently the main nutrients of concern and must be carefully managed as the input of these into a water body can significantly affect its quality. Consequently, there is growing social and regulatory pressure to mitigate the impacts of these. Understanding the N and 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 (NO_3^-), 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 shelter-belts impede run off. Research is underway to measure P run-off from kiwifruit orchards.

Recommended Practices for Sustainable Nutrient Management in Kiwifruit

In general terms, mitigation of nutrient losses involves applying the right fertiliser, in the right amounts at the right time, and in the right place. Some 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. Furthermore, 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

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 2/3rd prior to budbreak and the rest in late spring/early summer, prior to fruitset.

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 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 are also available, however like organic forms they may not supply sufficient nutrient when required and are usually more expensive.

For further reading see:

Nitrogen and Phosphorus are the two nutrients of focus: http://www.horizons.govt.nz/assets/horizons/Images/one-plan-tech-reports-public/nutrient%20loading%20technical%20report3%20-%20final%20draft_Jemmas%20edits.pdf

Best practice fertiliser use. Minimum nitrogen inputs, don't apply prior to lots of rain: http://www.fertiliser.org.nz/Site/code_of_practice/best_management_practices_considerations/fertiliser_use/best_management_practices_for_nitrogen_use.aspx

4.4.4 Climate Change

Impacts

Climate change is expected in New Zealand to lead to the following changes:

- **Higher temperatures**
  Greater increases in the North Island than the South, with the greatest warming in the northeast the amount of warming in New Zealand is likely to be lower than the global average
- **More frequent extreme weather events**
  Droughts (especially in the east of New Zealand) floods
- **A change in rainfall patterns**
  Increased summer rainfall in the north and east of the North Island increased winter rainfall in many parts of the South Island.
- **Rising sea levels**

The first three in particular have the potential to impact on kiwifruit production. The anticipated impacts are shown in the table below. For example, yield is expected to decline due to a decrease in winter chilling associated with less cold in the winter; a recent NIWA study showed that in 50 to 100 years, Hayward production in the Bay of Plenty would be significantly impacted due to less winter chill, especially in the absence of a budbreak enhance like Hi-Cane.

Table below: Summary of climate-change impacts for the main horticultural industries in New Zealand Chapter 6. Horticulture - Adapting the Horticulture and Vegetable Industries to Climate Change. In: Impacts of climate change on land-based sectors and adaptation options. MPI Technical Report Paper No. 2012/33. Prepared for the Ministry for Primary Industries by NIWA).

Temperature	Apples	Grapes	Kiwifruit
Temperature means ↑	Yield ↑ Quality ↑ Disease risk ↑ Sunburn ↑	Yield ↑ Quality ↑ Disease risk ↑	Yield ↓ Quality ↑ (and ↓) Disease risk ↑
Temperature extremes Frost ↓ Heatwaves ↑	Frost damage ↓	Frost damage ↓	Frost damage ↓
CO_2 ↑	Biomass ↑	Biomass ↑	Biomass ↑
Rainfall variability ↑↓	Irrigation ↑	Irrigation ↑ Drought risk ↑	Irrigation ↑
Water quality	Leachate load ↓	Leachate load ↓	Leachate load ↓
Extreme events • Hail - • Wind -	Damage to fruit - Damage to trees -	Damage to fruit - Damage to vines -	Damage to fruit - Damage to vines -
Combined impacts -	↑ Unless pest & disease impacts override	↑ Unless pest & disease impacts override	↑↓

Preparing for Climate Change

Adapting to climate change in horticulture can be considered using the following tri-level scheme.

- Tactical adaptation: This involves modifying production practices within the current system, which in horticulture might involve different sprays, irrigation practices, pest management strategies, or pruning practices.
- Strategic adaptation: At this second level, a change is made to the current production system in a substantive way which in horticulture might mean a change in cultivar, a change to the tree/vine support trellising system, or the installation of netting for hail protection or shade. As discussed above, climate change is expected to impact on current kiwifruit cultivars. In response to this, the kiwifruit industry's cultivar development programme is considering traits that will deliver new cultivars that are better suited to a changing climate. The includes a focus on greater pest and disease resistance and no reliance on bud-break enhancers.
- Transformational adaptation: At the highest level, adaptation involves adoption of a new production system, or a change in the location of the industry. In horticulture, this could be the development of new plantings of a new crop in a new region, or new plantings of an existing crop in a different region. This would also result in infrastructural changes. Potentially, climate change could see kiwifruit being grown in parts of New Zealand where it currently isn't due to 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.

Understanding the Contribution of the New Zealand Kiwifruit Industry to Climate Change

Carbon footprint represents the amount of greenhouse gas emissions, consisting primarily of carbon dioxide, associated with an organisation, event or production. It is one of the most common measures of the effect of an individual, community, industry, or country on the environment. An increase in greenhouse gas emissions is the primary event associated with climate change that has led to global warming (Source:http://www.livestrong.com/article/183436-the-importance-of-reducing-a-carbon-footprint/). Some businesses are interested in carbon foot printing as it allows them to identify efficiencies and in doing so save money. Globally the aim is to reduce greenhouse gasses.

In 2010, Zespri published the carbon footprint for Hayward ("Green") kiwifruit grown in New Zealand and consumed in Europe. This was 1.74kg of carbon equivalents per 1.0kg of kiwifruit across its lifecycle from orchard to consumer. The break down was as follows:

- Orchard operations made up 17 percent;
- Packhouse and cool store processes accounted for 11 percent;
- Shipping accounted for 41 percent;
- Repacking and retailer emissions made up 9 percent;
- Consumer consumption and disposal comprised 22 percent.

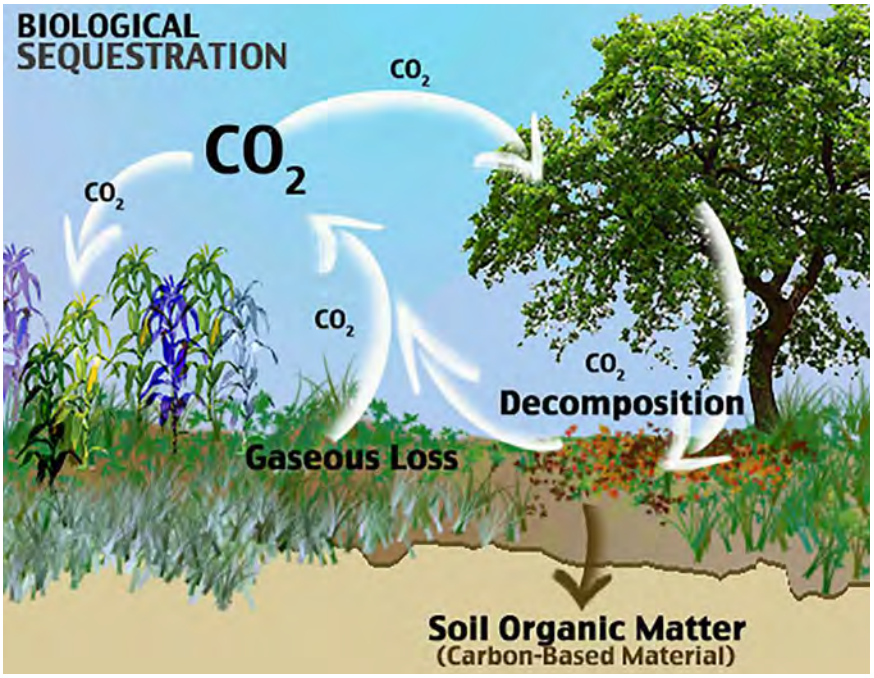
Zespri is in the process of reassessing the carbon footprint.

For more information, visit:
http://www.landcareresearch.co.nz/science/living/sustainable-business/carbon-footprinting/zespri

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. 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 kiwifruit orchards.

Right:
Biological sequestration



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.

Measuring and quantifying the role of soil carbon in relation to greenhouse gas emission associated with kiwifruit production is assisting industry in getting soil carbon recognised as a way of managing these emissions.

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. Firstly, it can deposit carbon from the roots not remobilised into the plant, and secondly, 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.

FOR FURTHER READING SEE:

Soil Organic Carbon in Kiwifruit Orchards - Contribution to Carbon Footprint Analysis, Soil Health and Mitigating www.plusgroup.co.nz/downloads/SFF_SOC.pdf.

4.4.5 Agrichemical Use

Agrichemical use in all horticultural systems 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 page 127)
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 (See chapter 4.5.1 for more information on 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 bodies 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.

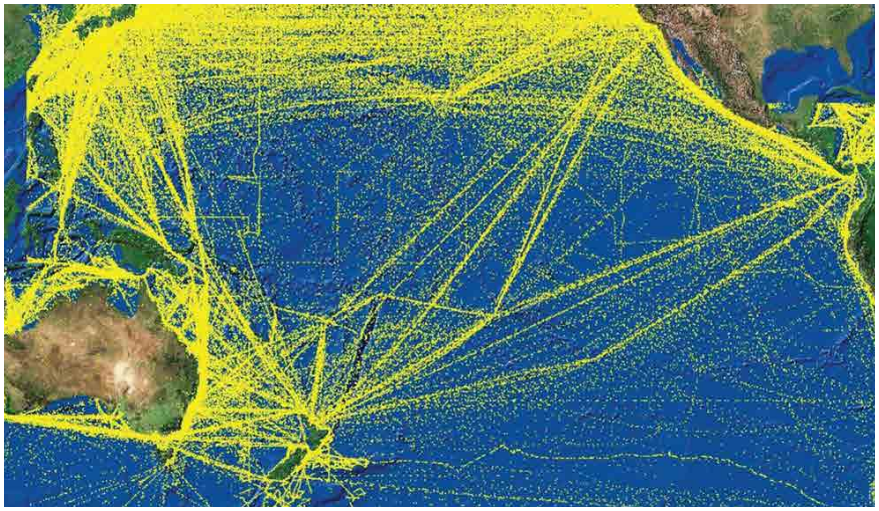
4.5 OUR COMMUNITIES

4.5.1 Biosecurity

International Shipping Routes

Worldwide, there is an increasing amount of kiwifruit loaded directly into containers at cool stores, before the containers are trucked to the wharf and shipped to receiving countries. Border officials must ensure that unwanted pests are not being transported to new locations by being lodged in vehicles, machinery, cavities in a container, or in soil, plant material or debris. The image below shows in yellow, the many and varied international shipping routes of vessels entering and exiting New Zealand's ports. Border officials at each port need to be highly vigilant to ensure unwanted organisms which are currently not present in New Zealand do not cross our borders.

Right:
Map showing world shipping movements in yellow



Brown Marmorated Stink Bug (Halyomorpha halys)

The Brown Marmorated Stink Bug (BMSB) is one of the kiwifruit industry's most 'unwanted' biosecurity threats. The risk of it entering New Zealand is considered extreme. During the 2018/19 high-risk season (September through to April) there were just over 200 live stink bug finds, mostly on ships and in people's personal effects.

BMSB can hitchhike on inanimate objects such as cars and shipping containers from Asia, USA and Europe. If it were to enter the country it would have no problem establishing due to New Zealand's highly suitable climate and abundance of host material. Its entry and establishment would result in significant production impacts to many horticultural industries. Kiwifruit is a host species and BMSB feeding results in fruit drop and post-harvest rot. Anecdotal reports suggest fruit loss could be up to 30% on some kiwifruit orchards.

30% fruit loss from some Italian kiwifruit orchards

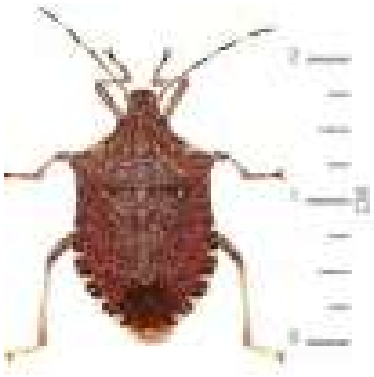
$3 billion impact on New Zealand's GDP

150+ bugs found at the New Zealand border in the summer of 2018/19

Identification

The BMSB has a shield-shaped body that is mottled brown with white banding on the antennae and alternating light/dark bands on the outer edge of the abdomen. Its body is 14 - 17mm long and emits a pungent odour when disturbed. BMSB are larger than other shield bugs found in New Zealand.

Right:
Adult BMSB with ruler to indicate large size



Far right:
Nymph and egg mass

The white or pale green cylindrical shaped eggs are laid on the undersides of leaves in clusters of about 25. The eggs are only 1mm in diameter but become apparent when nymphs emerge as they stay with the egg mass for several days. Nymphs are brightly coloured with black and white banding on legs, dark reddish eyes and yellow-reddish underbelly with black stripes.

Signs and Symptoms

BMSB feed on a wide range of plants with seeds or fruit including ornamental plants and vegetables. They pierce the outer surface of the fruit and suck out juices while injecting saliva, this causes dimpling on the fruit's surface and rotting and corking of the flesh. Adults are mobile and readily move from plants with early ripening fruit to ones with later ripening fruit. They seek shelter in houses/protected areas in autumn/winter. Egg masses and nymphs may be seen on the undersides of leaves.

Right:
BMSB feeding damage on an apple

Distribution and Climate Range

BMSB is now present across three major continents. It is native to Asia and found in China, Japan and Korea. In 1996 it invaded the USA where it has been found in 44 states and four Canadian provinces. In 2007, it was detected in Switzerland and 13 countries across Europe are now reported to have established populations. BMSB has been found in Santiago, Chile, the first population in the Southern Hemisphere. This potentially increases the risk to New Zealand given our seasonal alignment.

Right:
BMSB distribution shown in red

Figure 3. Distribution of BMSB (in red)

Control

Eradication of BMSB is extremely difficult and early detection is crucial for success. While traps are available for monitoring, these are not suitable for use in a surveillance network for early detection, like we have for fruit fly. Therefore, public reporting of suspect finds is critical.

Insecticides may be an important tool in an eradication attempt but are unsuitable for long term management given the residue issues that would be associated with repeat applications at high dosage rates. The most promising tool for BMSB management in New Zealand – if BMSB were to establish – is a parasitoid known as the Samurai Wasp, which is capable parasitizing over 80% of BMSB egg populations.

Right:
Nymphal stages of BMSB.
(Photo W. Hershberger)

HOW CAN I IDENTIFY BMSB?

There are currently other species of stink bugs found in New Zealand that could be confused with the Brown Marmorated Stink Bug (BMSB).

Key distinguishing features of the adult BMSB are:

- Its size (14–17mm);
- White banding on the antennae;
- Alternate black and white markings on the abdomen.

GIA (Government Industry Agreement)

The importance of being prepared for future biosecurity incursions is one of the biggest lessons the kiwifruit industry learnt from Psa. Although the industry responded well to the outbreak in late 2010, there is always the risk of another unwanted exotic pest or disease making its way to New Zealand's shores and affecting kiwifruit once again. The industry has a much better understanding of how to manage biosecurity risks, along with more tools to identify emerging risks. There is also a more engaged biosecurity relationship with government and increased capability to respond thanks to the formalising of the Government Industry Agreement (GIA) Deed 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.

***Pseudomonas Syringae* pv. *Actinidiae*, (Psa)**

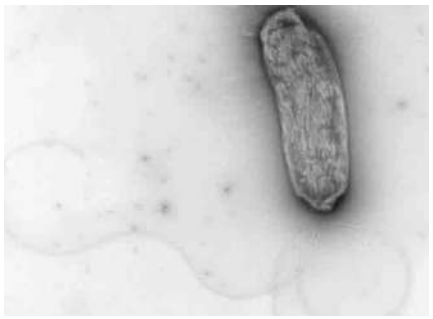
Psa is a bacterial disease that can kill kiwifruit vines. It carries no risks associated with human or animal health and does not affect plants other than kiwifruit vines. The greatest impact from Psa was felt in 2013/14 when grower payments were down 17 percent to $800.8 million due to a 55 percent reduction in volumes of Gold kiwifruit. Growers are now looking forward and having converted their orchards to a more Psa-tolerant gold cultivar, there is a general feeling within the industry that while Psa is here to stay, it can be managed.

Psa is a virulent form of the disease and 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 92% of New Zealand's kiwifruit hectares are on an orchard identified with the disease. It has been an extremely challenging period in the industry's history, significantly impacting orchards and kiwifruit production.

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.



Right:
Psa magnified 6000 times (KVH)

Far right:
Psa is rod shaped with flagella (KVH/ Plant and Food research)

Right:
Leaf spotting symptom of Psa (KVH)

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

4.5.2 Industry Response to Psa

Media Release

25 May 2016

Todd Muller

MP for Bay of Plenty

Muller welcomes stunning kiwifruit recovery and result

Todd Muller, Bay of Plenty MP says the Zespri result announced this morning is good for growers, good for Tauranga and good for NZ.

"Zespri and the kiwifruit industry need to be acknowledged. It was only a few short years ago the industry was under real pressure and they have turned it around superbly".

"The annual results announced today talk to leadership, discipline and collaboration from the orchard canopy to the supermarket shelves around the world".

"The results across all categories are powerful but the Green result is astonishing".

"That a fruit that has been around for 50 years, and to all intents and purposes at risk of commoditisation, has become through the Zespri system a premium global food brand is the stuff of Harvard Business Reviews".

"It is an industry that is still flat out with their 2016 harvest, but they do collectively deserve to reflect a moment on a job well done".

ENDS

The outbreak of bacterial disease Psa in 2010 was a severe blow to the kiwifruit industry. The industry was seriously questioning its future as the disease rapidly spread and growers watched helplessly as entire orchards were removed. 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.

The Establishment of Kiwifruit Vine Health (KVH)

See page 16 for an overview on KVH. For more information, go to www.kvh.org.nz.

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. Here is a video outlining the new kiwifruit cultivars which are Psa tolerant:

http://www.plantandfood.co.nz/page/news/video-index/video/breeding-psa-resistant-kiwifruit/

Research and Development Programme

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 kiwifruit industry. KVH and Zespri have already invested over $16 million in Psa research and innovation to understand how we can manage the disease, and $1 million is invested each year in research for other biosecurity threats.

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. To read more about the R&D programme go to: www.kvh.org.nz/psa_RD

Product Testing Programme

The KVH/Zespri product testing programme was developed 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 in the KVH/Zespri product testing programme. The KVH Recommended Product List is available for growers and includes products with proven Psa efficacy.

For more information about the Product Testing Programme go to: www.kvh.org.nz/producttesting.

For more information about the KVH Recommended Product List go to: www.kvh.org.nz/spray_information.

National Psa Pest Management Plan (NPMP)

The NPMP was established in May 2013 to help reduce the spread and impacts of Psa. Under the NPMP there are now industry rules governing disease management (including a year-round spray programme), monitoring, movement controls and the development of plans. These rules are outlined in a set of KVH Protocols available on the KVH website at: www.kvh.org.nz/protocols_movement_controls.

Kiwifruit Plant Certification Scheme (KPCS)

Long term growth and success of the kiwifruit industry requires biosecurity risks (including Psa) to be managed right across the supply chain – this includes kiwifruit nurseries. KVH introduced the KPCS in October 2016 to reduce the risk of pests and diseases being spread through the movement of nursery plants. By joining the KPCS, kiwifruit nurseries demonstrate they are managing biosecurity risks, have been independently audited, visually inspected for target organisms and returned a non-detected result for a very comprehensive testing regime for Psa.

Only KPCS-certified nursery plants may be bought, sold or moved between properties. However, growers may still produce plants on their own property for use on that property; and produce up to 1000 plants for movement between their own properties within the same Psa region.

For more information about the KPCS go to: www.kvh.org.nz/kpcs

On-orchard Biosecurity

Border biosecurity starts at the orchard gate. Growers are now aware that any equipment, vehicle or person entering their orchard could potentially introduce and/or spread Psa, not to mention other pests or diseases. Growers should have robust hygiene practices in place to protect their orchard; and anyone entering orchards should be aware of these measures.

To support this, KVH produced Kiwifruit Growers Biosecurity Guidelines in June 2019. The 5-step on-orchard biosecurity guidelines are a set of measures designed to protect a property from the entry and spread of pests and diseases and have been developed to provide guidance, help identify risks, and how to address them.

By using the guidelines to develop a biosecurity plan, growers are able to identify and prioritise biosecurity practices that are relevant to their orchard and property and are able to treat biosecurity planning in a similar manner to quality assurance or risk planning such as Health & Safety or emergency preparedness.

The five steps are:

- Understand your risks (what pests and diseases could arrive from offshore, who and what enters the orchard and might being them in)
- Agree what must happen on site (share knowledge and agree requirements)
- Source and trace clean plant material and keep tracking records updated
- Check and clean (sanitise high-risk items, ensure everything that comes on to the orchard is free of soil and plant material)
- Report the unusual to MPI or KVH immediately

For more information go to www.kvh.org.nz/guidelines

4.5.3 Positive Market Contribution

Our industry's foundations lie in the people who choose to be a part of our broader kiwifruit family. We know that without their collective efforts, whether that be on orchard, in the supply chain, or within one of our market-facing roles here at Zespri, the kiwifruit industry would not be able to achieve the success it does today. This sense of community defines our industry and it's important that we protect and enhance it. At Zespri, this means making sure that we continue to support organisations and projects that help strengthen our people and our communities. As our business and footprint across the world grows, so too must the contribution we make. The pillars in our community investment framework are:

- Happy and Healthy Communities,
- a Sustainable Environment,
- and a Skilled Workforce.

NOTES