# CHAPTER THREE
# ON-ORCHARD MANAGEMENT PRACTICES

This chapter is diverse, covering a range of orchard management practices. Firstly, the New Zealand kiwifruit growth cycle is explained, and basic orchard management practices are identified. Lastly, an overview of risk management is provided, such as the adverse events that may occur on an orchard.

## THE SECTION IS DIVIDED AS FOLLOWS

# 3.1 NEW ZEALAND KIWIFRUIT GROWTH CYCLE

The growing season for kiwifruit is long: up to 240 days. The New Zealand season begins with vine pruning in winter (June), which immediately follows the previous year's harvest. During the winter months (June to August) the vines lay dormant, allowing growers the opportunity to remove last season's fruiting canes and to select and tie down new canes which form the foundations for new growth.

Springtime (September to November) sees the kiwifruit vines begin to grow again. New shoots appear on the canes along with the first flower buds. When the flowers blossom, bees get to work pollinating the flowers. Pollinated female flowers transform into fruit.

As summer starts (December to February), kiwifruit vines undergo tremendous growth and growers frequently prune the vines to direct growth and manage the canopy (the canes can sometimes reach up to 5-6 metres in length during the growing process). The fruit grow quickly, and crop volume can be estimated. Growers selectively thin kiwifruit to optimise fruit size and taste (generally the less there are, the larger and tastier they grow).

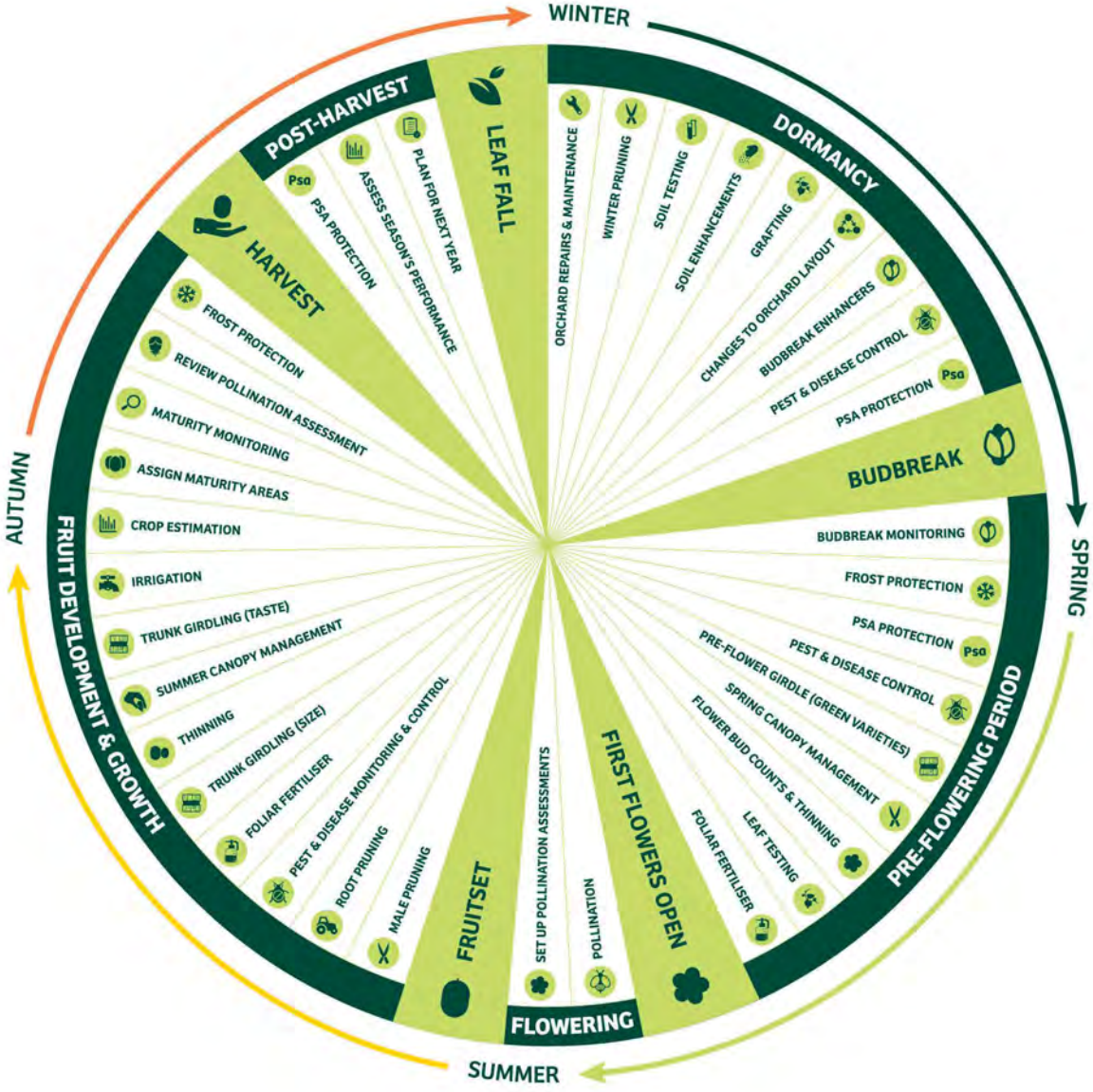
As the weather cools in the New Zealand autumn (March to May) harvest time approaches. The kiwifruit are tested for ripeness and when they pass a certain criteria for quality and grade, the kiwifruit are carefully picked by a huge team of workers. Once the kiwifruit have been picked, they are transported to the packhouse to be packed and stored ready for shipping and export. As the winter approaches, the leaves drop from the vines, signalling the end of another growing year. The vines move towards a dormant state and await the coming of spring.

Kiwifruit vines require sunshine, water, rich free-draining soil, with an ideal soil pH between 5 and 6.8 and winter chilling. To be productive, commercial crops require significant management. vine training, pruning, pollination, shelter from the wind and pest and disease control among other things all have a significant impact on the profitability and productivity of the crop. These management practices impact the size and the dry matter of fruit and the market acceptance of the fruit.

Below:
The New Zealand kiwifruit growing cycle showing the vine growth stage and orchard management practices on a seasonal basis

| Season | Winter | | | Spring | | | Summer | | | | Autumn | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | JUNE | JULY | AUG | SEPT | OCT | NOV | DEC | JAN | FEB | MAR | APRIL | MAY |
| | Dormant | | | Budbreak | | Flowering | Fruit set | | Fruit growth | | Leaf fall | |
| | Winter prune | | Budbreak sprays | | Bud and flower thinning + pollination | | Male prune | | Canopy management + thinning +girdling | | Harvest | |

"As summer starts (December to February), kiwifruit vines undergo tremendous growth and growers frequently prune the vines to direct growth and manage the canopy (the canes can sometimes reach up to 5 - 6 metres in length during the growing process)."



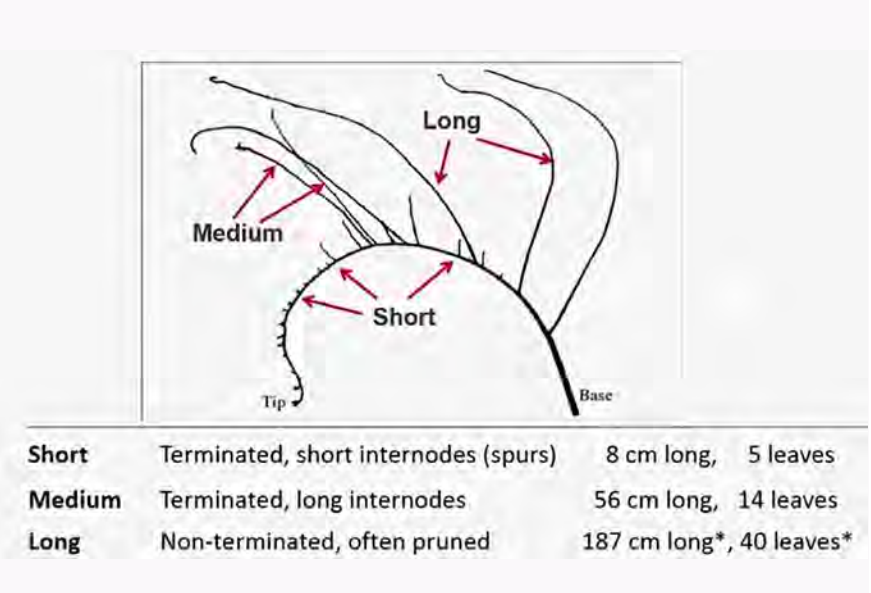

Above:
On-orchard kiwifruit production steps and key management actions

# 3.2 VINE MANAGEMENT – PRUNING

Pruning is one of the most important aspects of vine management and plays a major role in getting a consistent, quality yield each season. Successful management depends on good open pruning to prevent the vines becoming dense and tangled. Open pruning allows space for bees during the flowering period, penetration of sprays, air movement around the vines, and penetration of light throughout the vines to minimise the conditions which favour fungal disease such as Botrytis.

Open vines also provide adequate light needed to ripen the fruit and mature the fruiting canes for the following season. It is only under conditions of reasonable light penetration that new fruitful shoots will originate from the desired points on or close to the main leader. Good light levels and vital for dry matter and sugar level production in the fruit, it aids fruit size and enhances the storage life of the fruit. The figure below shows an example of the different types of fruit wood that growers need to manage.

Right:
Shoot types




| | | |
|---|---|---|
| **Short** | Terminated, short internodes (spurs) | 8 cm long, 5 leaves |
| **Medium** | Terminated, long internodes | 56 cm long, 14 leaves |
| **Long** | Non-terminated, often pruned | 187 cm long*, 40 leaves* |

## 3.2.1 Winter Pruning

Winter pruning can constrain orchard performance if it is not carried out correctly. Winter pruning is done after harvest when vines enter dormancy. The aim is to set up bays with optimal high-quality winter bud numbers on canes that are evenly spaced throughout the canopy.

Canes are tied down immediately after pruning. Even spacing has a great influence on the performance of the canopy the following summer. Consistent canopy density will reduce variation in fruit attributes (e.g. size, dry matter). The aim is to fill the canopy so there is an even cane spacing and no gaps. Even cane and spur spacing results in a consistent summer canopy that produces optimum fruit size and dry matter (climate and summer vine management allowing) and is easy to manage and achieve good spray coverage.

Right:
An even spread of high quality winter buds
*(Shane Max, Zespri OPC)*

## 3.2.2 Summer Pruning

Summer pruning involves removing excess vegetation from the vine during the growing season to: ensure good light levels on the fruiting canopy; ensure quality fruiting wood is produced for next year's canopy; reduce the amount of carbohydrates demanded by the actively growing canopy, thereby allowing resources to be redirected to the fruit; and to allow good spray coverage. The removal of excess growth also helps to prevent tangles and aids the development of next year's canopy which should in turn help to reduce work load and costs of winter pruning.

Pruning male vines during spring and summer keeps the vines compact so that they do not shade the female vines or cause tangles. As some male cultivars are more susceptible to diseases such as Psa, keeping a compact vine structure over summer also allows for better spray coverage.

Why are light levels important? Good light levels will keep all the leaves in the canopy functioning which will: enhance dry matter and sugar levels in the fruit; improve taste; maximise fruit size; and enhance the storage life of the fruit. An open canopy will also improve airflow and spray penetration, reducing the risk of pests and disease.

Right:
Grass growing beneath a well-maintained open light canopy
*(Shane Max, Zespri OPC)*

Far right:
Poorly maintained with low light levels have led to shading and leaf drop
*(Shane Max, Zespri OPC)*

Right:
Regrowth's and tangles in gold kiwifruit
*(Shane Max, Zespri OPC)*

Far right:
A non-terminated cane is shown on the left and a terminated cane on the right
*(Shane Max, Zespri OPC)*

The key to summer pruning is timing. Timing depends on several factors, including but not limited to: vine age; orchard environment; climate; canopy vigour; fertiliser use; the layout and structure of the orchard; and the size of the block. These factors will vary between and within orchards. Key considerations for achieving good results from pruning are:

- Tipping non-terminating shoots in the fruiting canopy to approximately four to six leaves past the last flower. The best time to do this is just as the earliest shoots begin to tangle.
- Removing vigorous excess canes as they will compete with fruit growth and increase shading.
- Terminated shoots do not need to be cut or shortened as these will not continue to grow or cause shading and are potentially the best cane to leave for next year's fruiting wood.
- Late growth (after flowering) should be removed as canes grown before flowering are often more fruitful than late grown canes.
- Shaded cane or spurs need to be removed, as wood that is exposed to sunlight will always produce more flowers and better-quality fruit.
- Canes growing back over the leader need to be removed as they are not optimal for vine structure and growth.

## 3.2.3 Zero-Leaf Pruning and Tip Squeezing

Both zero-leaf pruning, and tip squeezing are management practices that are used to help maintain optimal light levels and to reduce vegetative vigour.

**What is Zero-Leaf Pruning?**

Zero-leaf pruning involves pruning selected fruiting shoots just above the last (distal) fruit on a lateral so that there are no axillary buds from which secondary re-growth can develop. It helps manage excessive vine vigour and maintain good light levels within the fruiting canopy. If this technique is done correctly, the vines aren't too vigorous and virtually no re-growth will occur from the zero-leaf pruned shoot. This technique is primarily done to save on pruning costs. However, this increases the risk of Psa infection due to creating a soft tissue wound. Studies have shown that it doesn't have a negative impact on fruit quality but it is also unlikely to improve productivity or fruit quality.

**What is Tip Squeezing?**

Tip squeezing involves damaging the growing tip of actively growing shoots that would otherwise not self-terminate in spring and early summer. Tip squeezing prevents the shoot extending past a manageable length. Unlike straight pruning or removal of the tips which can stimulate secondary growth from lateral buds, tip squeezing leaves the shoot tip damaged but not broken, maintaining suppression of secondary growth while disabling the extension of the shoot. If undertaken, tip squeezing is conducted several times (approximately five times dependent on canopy vigour) throughout spring and summer and minimises the need to summer prune.

"If undertaken, tip squeezing is conducted several times (approximately five times dependent on canopy vigour) throughout spring and summer and minimises the need to summer prune."

## 3.3 BUDBREAK

**Growers have a variety of mechanisms to get sufficient yields of high quality fruit, these include:**

- Selection of high quality replacement cane in spring and removal of poor quality growth.
- Bud thinning – Defect buds are removed before they develop into flowers to conserve plant carbohydrates.
- Fruit thinning – Defect fruit are removed as soon as possible to ensure allocation of carbohydrates to high quality fruit.
- Girdling – Reduces competition for carbohydrates and ensures fruit attain maximum size and dry matter.
- Pruning – Removing unwanted vegetative growth early.
- Budbreak sprays.
- Constant use of best practice management throughout the season.

# 3.4 POLLINATION

Right:
Male kiwifruit flowers

Far right:
Female kiwifruit flowers

Pollination is an important aspect of commercial kiwifruit production. Kiwifruit are dioecious; this means that the pistillate and staminate occur on separate plants (male and female reproductive organs are on different plants). This makes pollination and the mix of male and female plants vitally important to achieving economic success. Successful pollination requires a sufficient number of male and female flowers which in turn requires a sufficient number of flower buds to have broken into blossom.

Financial returns are dependent on the number of fruit, their size, and the percentage of dry matter in the fruit, all of which are dependent on achieving adequate pollination. For example, the Zespri forecast return from August 2014 predicted that the value of increasing fruit weight by 1 gram could equate to the following financial returns:

- Green $800 per hectare
- Gold3 $1,700 per hectare
- Green14 $900 per hectare

However, achieving full pollination of kiwifruit flowers is difficult because:

- Pollen must be moved large distances as male and female flowers are borne on separate vines.
- Fruit size and the value of the crop is in part determined by the number of seeds the fruit contain which is dependent on the level of pollination.
- Female flowers need to receive thousands of pollen grains for full pollination (1,000 black seeds), unlike flowers of other fruit crops that only require a few pollen grains.
    - Green needs 12,000 pollen grains to achieve full pollination of 1,200-1,500 seeds.
    - Gold3 needs 6,000 pollen grains to achieve full pollination of 400-600 seeds.
    - Green14 needs 6,000 pollen grains to achieve full pollination of 1,400 seeds.
- Kiwifruit vines have relatively few flowers and require high levels of fruit set (>80%) compared to pip and stone fruit crops that need only a low percent fruit set.
- The flowers are not highly attractive to insect pollinators since they do not produce nectar.
- The vines flower late in the spring and consequently compete for insect visitors from other plants flowering at the same time.
- Kiwifruit vines were introduced into New Zealand from China, so they are without the insect pollinators with which they co-evolved.
- The crop needs high shelter belts to protect the vines from wind damage which reduces pollination by wind.
- In New Zealand, vines are grown close to the ground instead of up forest trees, (their natural habit) further reducing the level of wind pollination.

For these reasons the pollination of kiwifruit needs to be managed to a much greater extent than most other crops. This has resulted in the development of a pollination system for kiwifruit that is more sophisticated than that is used for almost any other crop in the world. The costs associated with pollination are also greater than for almost all other crops in New Zealand. Flowering and pollination occurs in spring, but the timing varies by region, altitude and variety. Most kiwifruit orchards are pollinated by bees. To prevent bees from searching to find nectar, bee keepers and/or growers who are managing the bees, feed the bees a mixture of sugar and water at dawn and dusk. Bees feed on the sugar and water mix as a substitute for nectar and can spend more time searching for kiwifruit pollen which increases bee movements and visits between male and female kiwifruit flowers. As bees find more attractive nectar sources they tend to spend less time pollinating kiwifruit, therefore beekeepers can swap out their hives after a few days so that they remain focussed on collecting kiwifruit pollen.

Growers also supplement beehives by applying additional pollen to kiwifruit vines throughother means . This activity is called 'artificial pollination'. Growers can have the flowers on their male vines picked and processed so the pollen can be used for artificial pollination. There are also growers whose business is to grow male kiwifruit vines for the production of pollen to use in the pollination of female kiwifruit vines. It is important to acknowledge that all cultivars of male kiwifruit vines are not always compatible with all cultivars of female kiwifruit vines. Known male kiwifruit vine cultivars used in New Zealand include: Chieftain; Matua; King; M56; M33; M91; Toumuri; Russell. New males are developed under the Zespri/Plant & Food Research Breeding Programme. The aim of this programme is to breed specifically for male characteristics such as Psa tolerance, flower numbers, pollen fertility, a long flowering period, attractiveness to bees, and low vigour.

Below:
Two traditional double box hives used for kiwifruit pollination

There are a number of key things that growers consider when deciding to use artificial pollination. Stigma receptivity, bee activity, the presence of overhead shelter, the rate of pollen to apply per hectare and the costs involved both pollen and labour. A major consideration is whether the extra cost of artificially applying pollen will increase financial returns.

There are many pollination devices that growers can use to apply pollen and are categorised into three broad groups:

- Contact application – like hand pollination
- Wet application – spraying pollen onto the flowers
- Dry application – blowing the pollen on

Right:
Devices which can be used for applying dry pollen to kiwifruit

Quad Duster

Recycling Duster

Handhold Duster

Hand Held Blower

**READ MORE HERE:**

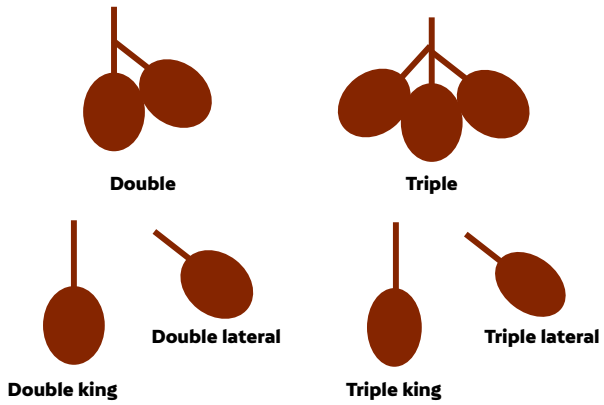
http://sciencelearn.org.nz/Science-Stories/Seeds-Stems-and-Spores/Pollinating-kiwifruit

http://sciencelearn.org.nz/Contexts/Pollination/Sci-Media/Video/Artificial-pollination

http://www.pollenplus.co.nz/pollination-benefits.html

## 3.5 THINNING

Thinning is undertaken multiple times throughout the growing season to get the optimal amount of exportable yield. Too many fruit on the vine can reduce the overall quality of the fruit by reducing average fruit size and taste. Thinning can start as soon as buds develop. Defect flower buds are removed before they develop into flowers. Removal of defect flower buds aids pollination as bee visits are not wasted on flowers that will not become exportable fruit. It is best practice to set the desired number of buds in winter pruning, it minimises flower/fruit thinning costs and doesn't compromise fruit dry matter.




Right:
Which fruit is king fruit and which is lateral?

During thinning, growers target a number of areas. They include:

- The removal of low value fruit (misshapen, damaged, undersize).
- Adjust fruit load per shoot to obtain minimum leaf: shoot ratios (2-3 leaves per fruit).
    - Spurs 1-2 fruit (approx. 5 leaves).
    - Medium terminated shoots 2-6 fruit (7-21 leaves).
    - Long terminated shoots 4-6 fruit (14-40+ leaves).
- Removal of lateral fruit as the king fruit is always larger and has higher dry matter than the lateral fruit.
- Remove more fruit from heavily shaded parts of the vine as this fruit tends to be of lower dry matter.

The figure above is a visual illustration of the fruit thinned off. When there are two fruit growing together the fruit which is growing on the side (lateral) is removed as it will never be as big as the king fruit (the fruit in the centre). The lateral fruit will reduce the size and the dry matter accumulation of the king fruit. The same is true if all three fruit are together in a triple, the two fruit either side of the king fruit are removed.

# 3.6 GIRDLING

Trunk girdling of kiwifruit is used to increase dry matter, increase fruit weight and increase the number of flowers the following season. The process works by isolating roots, in the period when the girdle is open, so that they cannot compete with the fruit for the carbohydrates produced by the leaves.

Kiwifruit growers often apply a girdle during both spring and summer of the same season. A girdle applied in the spring increases fruit size. The summer girdle allows the fruit to attain a higher dry matter and can increase return bloom in some varieties. A pre-flowering trunk girdle is used by some growers to prevent or halt flower bud infection caused by bacteria, like Psa, in green cultivars.

Trunk girdles are easy to apply, with the use of a tool or a girdling chain. The tool is a double-bladed knife which cuts and removes a thin slice of bark from the circumference of a stem and the chain is a blunt chainsaw chain with a handle at each end that is pulled back and forth to remove the wood.

Technique is important, if the girdle is too shallow and has not gone through the phloem, the root system will still be able to compete with the fruit. If the girdle is too vigorous and cuts through the xylem it will disable the supply of water and nutrients to the canopy. The girdles will also be slower to heal, and vines will be at greater risk of disease infection.

Far left:
Severe girdle-cut through both the phloem and xylem. Pen shows where girdle should have finished (*Shane Max, Zespri OPC)*

Centre left:
Correct girdle (*Shane Max, Zespri OPC)*

Centre right:
Three healed girdles (*Shane Max, Zespri OPC)*

Far right:
Chain used for girdling (*Shane Max, Zespri OPC)*

Below:
Girdling knife

The key is to remove all of the phloem down to the xylem around the entire stem. It can be easy to spot a girdle that has not removed all of the phloem connections – when phloem tissue is cut it turns very quickly from white to brown as the cells oxidise. If there is a fresh girdle where a part of the trunk girdle is too shallow the phloem tissue would be brown and the rest of the girdle would stay white indicating that it had correctly reached the xylem. The xylem goes brown much more slowly.

Using a tool it can take 10-14 hours to girdle a hectare of single planted mature vines, although this depends how thick and rough the bark is. Additional time will be required if the vines are double planted (two vines per bay). The chain is a lot faster, but it comes with higher risk of xylem damage and Psa expression. It is recommended that the chain is not used on young vines and cultivars that are more sensitive to Psa.

The cost can range from $240-$340/ha, but the benefits in increased fruit weight, dry matter and return bloom can be significant. Increase in gross orchard income of $2,000/ha, $11,000/ha are easily achievable for Hayward and Gold3 orchards respectively, this is dependent on fruit prices and level of response. This potential additional gross income comes about from an increase in fruit size (more fruit in higher paying larger counts) increased yield (more trays of larger fruit mean fewer fruit are required to fill a tray) and an increase in fruit dry matter. At 2014/2015 prices, a one percent lift in dry matter is worth $400 and $1,600 per 1,000 trays for Green and Gold varieties respectively. Growers may also receive additional payments for being early in the season. It most situations, it is likely that the cost to apply a trunk girdle would more than be covered by the potential financial gains.

## 3.7 ROOT PRUNING

Root pruning should not be confused with soil ripping, which is used to improve soil structure and drainage on heavier soils. Root pruning is used to increase fruit dry matter, this is achieved by cutting off roots and reducing the size of the root system, which in turn reduces the carbohydrate demands of the root system making more available for fruit growth and dry mater accumulation.

Right:
Root pruning is done with a large blade attached to the back of a tractor that drives slowly down the rows and cuts down into the soil

Far right:
Ripper attached to the back of a tractor, used to help improve soil drainage (*Shane Max, Zespri OPC)*

## 3.8 CROP PROTECTION

The Zespri Crop Protection Standard advises growers which agrichemical compounds may be applied to fruit that will be marketed by Zespri. There are different standards for conventional and organic production systems. These standards ensure fruit meets the legal requirements in each country where Zespri fruit is sold and that customers and consumers requirements for safe fruit, produced in an environmentally responsible manner, are also met.

### 3.8.1 Integrated Pest Management

Kiwifruit are susceptible to a range of pests and diseases which can affect vine health, fruit quality, or restrict access to important export markets. The best method for crop protection is an integrated pest management approach that includes:

- Monitoring for pests and diseases.
- Applying appropriate agrichemicals at the right time and at the correct concentration.
- Using cultural controls to further minimise pests and diseases.
- Implementing orchard hygiene measures to prevent the spread of pest and diseases.

## 3.8.2 Agrichemical Controls

Pest and disease control using agrichemicals is an essential part of modern orchard management. Pests such as scale and leafroller and diseases such as Psa and Sclerotinia often require agrichemicals to control their numbers. Agrichemicals should only be applied if they are required, therefore monitoring for pests is essential for growers to determine what agrichemicals they should be using.

Agrichemicals for pest and disease control can be grouped into three categories: systemic, contact and preventative. Systemic agrichemicals travel through the plant after they enter through healthy leaves, where they can poison or disrupt the lifecycle of pests and diseases. Contact agrichemicals rely on excellent spray coverage, as they depend on touching the pest or disease that they target. Preventative agrichemicals tend to make the plant unappealing to a particular pest or disease, by methods such as altering the taste of the plant or changing the pH of the leaf surface.

Right:
Sprayer applying an agrichemical to dormant vines in winter


## 3.8.3 Cultural Controls

Cultural controls are often simple non-chemical methods which results in more effective control of pests and diseases. Examples include removing one large crown per vine during winter pruning to reduce the number of crevices where scale can hide or allowing the grass sward under the vines to grow long during flowering to reduce the ability of *Sclerotinia* spores to drift from the ground up to the canopy.

## 3.8.4 Orchard Hygiene

Keeping tools and equipment clean and sanitised is a key strategy for minimising the spread of pests and diseases. Virulent diseases such as Psa can spread from vine to vine on pruning tools and can move between regions through new plants or budwood; soil-borne diseases can be transported onto an orchard in mud on boots or tractor tyres; and pests can be transported in machinery imported from other countries. Sterilising pruning and girdling tools between every vine, using foot baths when entering an orchard, and thoroughly cleaning machinery can all help to prevent or slow down the spread of pests and diseases.

## 3.9 ORCHARD-RISK MANAGEMENT

It is important the growers plan risk into their business model to ensure sustainable profitability. The following diagram illustrates some of the immediate risks growers should take into consideration. Please note that there are wider risks which also impact upon grower profitability such as market access or geopolitical changes. Below is a diagram outlining the various risks that growers could encounter throughout their orchardist careers.

### Immediate risks to growers