# 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. Fruit is 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. The aim is production of a crop of relatively uniform high dry matter fruit of the size preferred by markets.

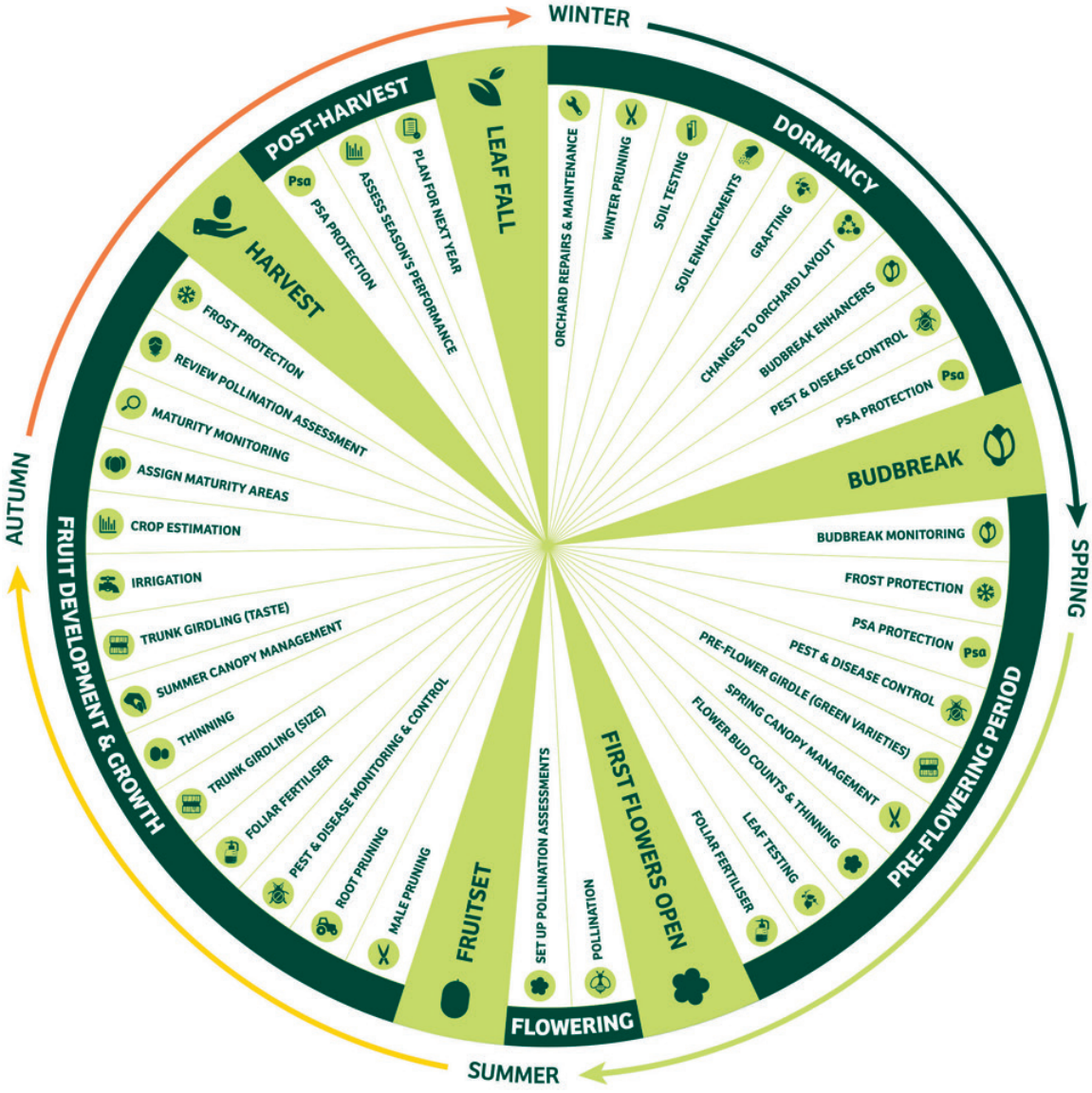
**Growers utilise a variety of mechanisms to get sufficient yields including:**

- Selection of high-quality replacement cane in spring.
- Pruning – Removing poor quality and unwanted vegetative growth early.
- Budbreak sprays.
- Pollination.
- 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.
- Control of pests and diseases.

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)."



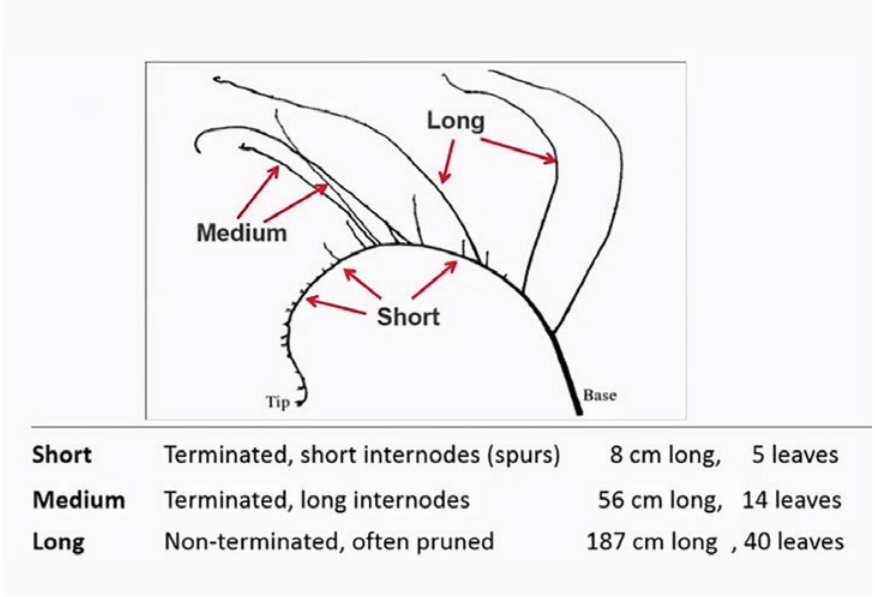

Above:
On-orchard kiwifruit production steps and key management actions

## 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 Sclerotinia.

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 |

### 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)*

# 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.

# 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 are not 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 (or crush tipping) 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."

Right:
A strong shoot about to be zero-leafed

Far right:
An actively growing shoot tip prior to squeezing (left), and the controlled damage of the intact shoot tip following squeezing (right)

## 3.3 BUDBREAK

Budbreak refers to when the buds on dormant canes open and start growing shoots and then flowers in Spring. Timing and quality of budbreak depends on winter chilling. Winter chilling is measured from the start of May each year (typically measured as the number of hours below 7° Celsius or the average temperature across May, June and July). Timing of budbreak is affected by temperatures up to the start of budbreak, but number of flowers can be affected by temperatures between budbreak and flowering. The colder the winter, the earlier budbreak will begin, and the more king flowers will come from each bud.

There are advantages in having a more uniform budbreak across a production block, as well as maximising the number of quality flowers while minimising the spread in timing of flowering. Several different chemicals can be applied to the vines during dormancy to enhance budbreak, the most frequently used being Hydrogen Cyanamide (marketed under different trade names, the most common being Hi-Cane). These products can make up for reduced winter chilling, allowing for kiwifruit production in warmer parts of the country and in the future with warmer winters.

Timing of application is critical with budbreak enhancers. Hydrogen Cyanamide is most effective when applied 35-25 days before natural budbreak. Determining when that budbreak "day" will be can be difficult (natural budbreak takes 10-30 days to complete). It will vary by region, but wood quality, cropping history and orchard management can also impact on timing of budburst. Models exist based on mean monthly temperature data from previous years, but it is not an exact science. Gold3 and Red19 have earlier budburst than Hayward.

The Environmental Protection Authority (EPA) began a reassessment of the use of Hydrogen Cyanamide in 2020, relating to the hazards and risks of the substance. NZKGI are leading the industry response in providing information on the use of Hydrogen Cyanamide to the EPA. The reassessment process is long and complex, so any outcome is not expected before 2022.

Right:
Stages of bud break.

# 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 female (pistillate) and male (staminate) reproductive organs occur on separate plants. This makes pollination and the mix of male and female plants on orchard vitally important to achieving economic success.

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. Pollination is managed to a much greater extent in kiwifruit than in other crops, and the costs involved are also greater.

**Achieving full pollination of kiwifruit flowers is difficult:**

- Pollen must be moved large distances as male and female flowers are borne on separate vines.
- Male flower pollen release and Female flower receptivity is not always synchronous. Different male cultivars flower at slightly different times from October to December. Hayward female flowers, once open, are receptive for 6-7 days with bud-burst enhancer use (10-15 days without), Gold only 2-3 days. Exact timing of flower opening depends on region, altitude, and season (average temperature).
- Female flowers need to receive thousands of pollen grains for full pollination, 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.
- It takes many bee visits to each flower before full pollination is achieved (up to 40 bee visits for Hayward flowers, 6 for Gold).
- Fruit size (and therefore the value of the crop) is in part determined by the number of seeds the fruit contain. Export size Hayward fruit contain at least 800 seeds (usually 1000-1400), Gold at least 100 seeds.
- Kiwifruit vines have relatively few flowers and require high levels (>80%) of fruit set (a flower becoming a fruit) 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.
- Some varieties flower late in the spring and consequently compete for insect visitors with other plants flowering at the same time.
- Kiwifruit vines were introduced into New Zealand from China, so they are without the natural 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.

Kiwifruit orchards are pollinated by bees. Very few growers maintain their own beehives however, most relying on the beekeeping industry to supply hives for the few weeks over flowering/pollination. The number of hives, when they are brought in, and their positioning is important. Stocking rates will vary (9-12 hives/ha); less for orchards surrounded by other orchards, more for isolated orchards. In Green orchards the bees are bought in once 20-30% of female flowers are open, earlier in Gold orchards. Sunny sheltered sites help encourage bee activity.

Kiwifruit flowers do not have nectar, the usual reward for pollinators, they are only attractive because of their pollen. As a result, beekeepers supplement the bees with a sugar and water mix to reduce the chance of them foraging beyond the orchard. It is important that growers remove other flowers from the orchard and surrounding areas during pollination e.g., by mowing the sward.

Many agrichemicals are toxic to bees so crop protection sprays must be avoided or timed very carefully during flowering/pollination. Overhead cover e.g., for frost or hail protection, can also disrupt bee navigation.

Growers supplement beehives by applying additional pollen to kiwifruit vines through other means. This activity is called 'artificial pollination'. Male-only orchards are used to produce commercial supplies of pollen or growers can have some of the flowers on their own male vines picked and processed before the female flowers open. The cost of pollen varies (± $5000/kg in 2019), partly due to flower collection being extremely labour intensive, with 100kg of male buds needed to produce 1kg of pollen. The amount of pollen used will also vary with the situation, and the number of applications.

Below:
Two traditional double box hives used for kiwifruit pollination

**Methods of artificial pollination include:**

**Wet application** – spraying a pollen/water mix directly on to female flowers. This method tends to be more labour intensive but is useful when bad weather reduces bee activity or there are no bees.

**Dry application** – blowing pollen onto the canopy which is then redistributed by bee activity. This method may be less labour intensive but there can be considerable wastage of pollen.

**READ MORE HERE:**

https://www.sciencelearn.org.nz/resources/99-pollinating-kiwifruit

https://www.sciencelearn.org.nz/videos/19-artificial-pollination

## 3.5 THINNING

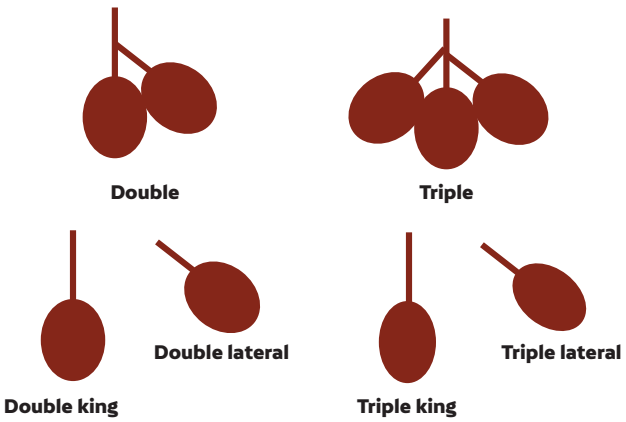
Thinning is undertaken multiple times throughout the growing season to get the optimal amount of exportable yield. Too many fruit on the vine can reduce the overall quality of the fruit by reducing average fruit size and taste. Thinning can start as soon as buds develop. Defect flower buds are removed before they develop into flowers. Lateral flower buds are removed as the fruit they produce is always substandard to that of the king flower. Removal of these buds aid 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:
Removal of lateral flower buds is ideal before pollination.

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.

A final round of thinning may be completed to remove fruit with obvious defects (flats and fans, hayward mark (green), blemish that is dark coloured and larger than 1cm$^2$) and soft or damaged fruit before it is harvested as such fruit incurs expense when it must be removed during packing.



# 3.6 GIRDLING

Trunk girdling is used to increase dry matter, increase fruit weight, and increase the number of flowers the following season. Girdling refers to the removal of a thin strip of bark from around the circumference of the vine trunk or cane. This bisects the phloem so prevents the flow of carbohydrates to the roots, meaning more is allocated to the fruit in the time that the girdle is open. The plant grows a callus that heals over the girdle, reconnecting the phloem, usually within a few weeks.

Girdling is carried out at least twice in a 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 trunk. The chain is a blunt chainsaw chain with a handle at each end that is pulled back and forth to remove the bark.




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)*

Right:
Girdling knife

Technique is important. If the girdle is too shallow and has not gone through the phloem (the cambium), the root system will still be able to compete with the fruit. If the girdle is too vigorous and cuts through the xylem (the wood) 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. Shallow girdles are easily identified as the left-over phloem material oxidises quickly and turns brown. Using a girdling chain is generally faster but comes with increased risk of xylem damage.

Hygiene is crucial with either method: both tools and chains should be sanitised between plants, and the girdling cuts should be sprayed with a protectant solution (e.g., copper) as soon as they are completed. There is some evidence from trials in Europe that girdling may act as an elicitor and activate the plant's internal bacterial defence response, this reducing their susceptibility to Psa.

## 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 of the vine, which in turn reduces the carbohydrate demands of the root system making more available for fruit growth and dry mater accumulation. The prune is completed via a large tractor-drawn pruning blade that cuts through the roots (approx. 40cm deep) on both sides of the vine. For best results root pruning is used alongside trunk girdling. Usually, a root prune is applied in January.

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.

### 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.

## 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


## 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.

## Orchard Hygeine

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