CHAPTER TWO
ORCHARD DEVELOPMENT

There are around 12,905 hectares of kiwifruit vines that have been established in New Zealand over the last 100 years. The development of kiwifruit orchards has significantly advanced over that time, particularly in the last 10 years. This chapter identifies important aspects of orchard development.

THE SECTION IS DIVIDED AS FOLLOWS

2.1 GREENFIELD CONVERSION

A greenfield conversion is when land used for farming or another use is converted to a kiwifruit orchard. Prior to any land purchase, consideration must be given to water consent requirements in the area.

The conversion process involves initial capital cost of:

- Site preparation (with possible contouring)
- Establishment of shelter
- Establishment of water supply and reticulation
- Planting of rootstock and grafting kiwifruit or planting pre-grafted kiwifruit plants
- Support structures, initially post and wire then pergola (usually steel agbeam)
- In some orchards, frost protection (via water or windmill) and overhead hail protection may be included

Once the initial capital work has been completed, vine and orchard maintenance is required to establish the orchard to the producing stage in around three years. Consideration needs to be given to lack of return for a period of 3-5 years before orchards reach maturity and are covering their annual growing costs.

2.2 SUPPORT STRUCTURES

Kiwifruit vines need to be trained onto a support structure for commercial cultivation. The most commonly used support structure is the pergola system. Historically, vines have been grown on a T-Bar system which was cheaper to construct and easier to maintain. However, greater yields are achieved on pergola structures and most orchards are now grown using the pergola system.

Right:
A young kiwifruit vine growing on a pergola system
(Shane Max, Zespri OPC)

Right:
Grafted kiwifruit stumps with pergola structures and wires in place ready for training
(Shane Max, Zespri OPC)

Far right:
Kiwifruit growing on a pergola system

Right:
T-Bar grown kiwifruit vines

Far right:
T-Bar to pergola conversion kiwifruit vines
(Shane Max, Zespri OPC)

2.3 SHELTER

It is important to have shelter established before kiwifruit vines are planted. Kiwifruit vines do not tolerate wind well. Good shelter should reduce wind speeds in the orchard which will also increase the temperature providing a warmer, protected environment for plants. Without shelter young vines will be stressed and slower to develop. Cooler temperatures can cause decreased growth and smaller leaves while a windy environment will lead to increased physical damage on young plants. In an established orchard reduction in wind speed will raise orchard productivity through improved growth and reduced damage. Shelter decreases the number of fruit rejects due to wind rub, especially on skin sensitive Gold varieties. Additionally, shelter offers protection to new growth in spring preventing blowouts of shoots and physical damage on canes that can be entry points for Psa infection. Increased temperatures during flowering can also encouraging bee activity, and promote normal flower and fruit development. During summer when vines typically require more water, reducing wind speeds reduces evapotranspiration, decreasing how much water the vines require in windier seasons.

Types of Shelter

Natural shelter (e.g. tree shelterbelts) is used extensively in New Zealand. Natural shelter is low cost but takes time to establish. Kiwifruit vines need the most protection when the vines are developing and if natural shelter is being grown at the same time as young kiwifruit vines, it will not provide adequate protection. Natural shelter comes with regular maintenance costs, including trimming, mulching and spraying for pests. It also takes up productive land area and can compete with vines for nutrients, sunlight and water.

Artificial windbreaks can be used to increase shelter while not limiting light and still maximising productive land area. Artificial shelter is more expensive to install than natural shelter, but gives an immediate solution, rather than waiting for natural shelter to establish. While the annual maintenance costs are lower compared with natural shelter, the shelter cloth usually has a ten-year warranty, so the maintenance costs beyond ten years may be much greater than natural shelter. Overhead shelters cover kiwifruit vines typically with hail netting on the roof and wind break cloth on the sides. Overhead shelters have an expensive outlay cost, but the financial rewards can be significant. The benefits include:

- eliminating the impact of a hail event provided the cloth is in good condition;
- a significant reduction in wind speed;
- elimination of wind turbulence;
- reducing leaf wetness and vine damage minimising the spread of Psa and risk of Psa infection;
- and improved pest control.

Right:
Trees planted for natural shelter
(Shane Max, Zespri OPC)

Far right:
Internal shelter helps to keep temperatures up reduce wind and improve the growth of developing vines
(Shane Max, Zespri OPC)

Growers have reported improved pest control with the elimination of susceptible shelter species that can harbour pests such as leafroller, scale and passion vine hopper. There are also reports of improved cicada control in using overhead shelter as emerging adults do not like the enclosed canopy and immediately fly to one end and attempt to exit. Overhead shelter has been associated with greater bee mortality and decreased pollination with traditional pollination systems. Ongoing research is revealing new strategies for improving pollination while maintaining hive health.

Right:
The erection of hail netting over an orchard. In this instance the structure also has enclosed sides

> “It is important to have shelter established before kiwifruit vines are planted. Good shelter raises orchard yields through improved growth.”

Right:
Perimeter artificial shelter
(Shane Max, Zespri OPC)

Far right:
Internal artificial wind breaks have removed the need for natural shelter and so increasing the productive area
(Shane Max, Zespri OPC)

2.4 IRRIGATION

Young developing vines require constant watering to help develop healthy leaf growth and root systems. Irrigation requirements are variable throughout New Zealand. Soil type is a significant factor in determining how much and how often a block of kiwifruit is watered. Variation of soil types within an orchard requires some precision irrigation so that water is not wasted and vines are not stressed. Soils with a high proportion of pumice will drain more quickly than soils with a high proportion of clay and will require more frequent watering. Kiwifruit vines that run short of water, especially during phases of rapid growth, will wilt and the leaves will quickly go brown. Kiwifruit vines suffering from drought will produce smaller fruit and excessive drought can reduce the following seasons yield.

Right:
Sprinkler used for irrigation
(*Shane Max, Zespri OPC)*

Excessive irrigation, particularly in clay soils, can also be detrimental to the productivity of kiwifruit vines. Kiwifruit roots are sensitive to a lack of air and if the roots remain under water for 24-48 hours it will result in root death from which the vine is slow to recover. Irrigation can also be used as tool to increase fruit size prior to harvest. This is managed with caution by growers because although water increases the fruit size it also reduces the fruits dry matter. Growers are paid using both measures. Irrigation can also be used for frost protection.

2.5 FROST PROTECTION

Frost damaged fruit are not edible or saleable and frost damage to vines can negatively impact productivity of kiwifruit vines the following season. Gold and Red varieties are more at risk of spring frost damage as budbreak occurs earlier than in Green. Hayward fruit is more susceptible to autumn frost damage as they are generally harvested later.

Nearly all the horticulturally significant frosts in New Zealand are of the radiation type (rather than advection frosts). Radiation frosts occur on nights with clear skies and little or no wind. As heat is radiated away from the ground and vegetation surfaces, the warmed air rises and is replaced by cold air moving down. This creates an inversion layer. This cold air draws further heat from the plant material. When the cold air is below 0° Celsius a frost occurs, which can result in irreversible damage to the plant tissue.

There are three main types of frost protection: heating, mixing (to disturb the temperature inversion) and radiation barriers. In Kiwifruit, the most widely used methods are sprinkler systems (heating) and wind machines (mixing).

Right:
Severely frost damaged kiwifruit leaves
(*Shane Max, Zespri OPC*)

Far right:
Ice on kiwifruit
(*Shane Max, Zespri OPC*)

Heating

Sprinkler-based frost protection systems are most common and use the heat released when water changes state from a liquid to a solid. Spraying water at an appropriate rate onto a crop under frost conditions causes a layer of ice to slowly develop over the vines. Provided the surface of this ice layer is kept wet, the temperature of the enclosed plant tissue will not drop below about minus half a degree, even though the surrounding air may be at a much lower temperature. This requires a considerable amount of water (approx. 1-3mm/hr/ha or around 300,000L/hr on a 10ha orchard, greater than the flow rate required for irrigation) so well-draining soils are critical.

An older method of frost protection is direct heating by portable heaters and/or frost pots, fuelled by combustion (oil, natural gas, LPG, special solid fuel blocks, candles made from wax, compressed wood waste or other similar materials). Effectiveness decreases with distance from the heat source.

Right:
New growth protected from frost damage by a sprinkler system

Mixing

A wind machine or frost fan is essentially a large fan at the top of a 10 or so metre high tower, located in the centre of the area to be protected. The 'jet' of air produced by the fan draws the warm air from above the orchard and mixes it into the colder air closer to the ground. Depending on topography and block layout, one fan can protect an area of 4-6 ha. Flying a helicopter at relatively slow speed across the orchard area can also effectively mix the air and provide frost protection. The advantage over wind machines is that the helicopter can concentrate on selected areas if required and fly at greater elevations to provide added mixing capability. There are noise considerations with both methods.

Right:
Windmill used for frost protection (*Shane Max, Zespri OPC)*

Far right:
Helicopters used for frost protection

Radiation Barriers

The principle of a radiation barrier is to reduce the heat radiated from the vines and soil surface, and hence increase the vine temperatures. This is achieved by intercepting the outgoing radiation by means of frost cloth or similar.

Right:
Overhead shelter
(*Shane Max, Zespri OPC)*

Cold Air Drainage

Since cold has a greater density than warmer air, it settles at the lowest point that it can easily flow to. In kiwifruit orchards, natural or artificial shelter can trap cold air so that it pools, where it can lead to frost damage. Maintaining cold air drainage involves modifying downhill shelter so that cold air can freely drain out of the orchard. This can include removing the lowest metre of foliage from natural shelters so that cold air can flow under, or repositioning shelter to allow for cold air to escape.

For more information: *New Zealand Kiwifruit Journal* Issue 262, August/ September 2020

2.6 ROOTSTOCKS AND GRAFTING

Kiwifruit cultivars that produce desirable fruit do not necessarily have good root systems or resistance to disease. For this reason, commercial kiwifruit plants are not grown from seed but are the result of grafting a good fruit-producing cultivar (termed the scion) onto another cultivar with better root growing capability (the rootstock). The rootstock can also impart its characteristics on to the scion, such as low vigour in vegetative growth.

The two most common rootstocks in kiwifruit are Bruno and Bounty (also called Bounty71). Bruno was a commercial cultivar itself up until the 1970s, when Hayward took over due to its better storing properties. Bruno rootstock is grown from open pollinated seed so retains some level of variability. It is hardy, easy to propagate and resilient – particularly in its resistance to Psa. Bounty is a clonal rootstock i.e. it is propagated through cuttings (cloned) so has very little variation in its attributes. While Bruno is used for both Gold3 and Hayward plants, Bounty is not recommended for Hayward due to its lower vigour and lower Psa resistance. However, when used with Gold3 it increases flowering and slightly reduces vegetative growth. Rootstocks can confer tolerance to climatic and environmental challenges such as waterlogging, drought, extremes in temperature and poor-quality soils. This has allowed for kiwifruit production to spread into more marginal growing areas and may in the future mitigate the impacts of climate change.

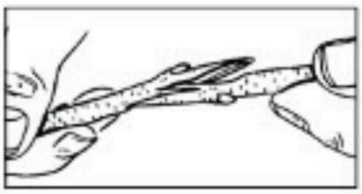
The choice of rootstock can also impact on the timing of the vines development throughout the season (phenology). Gold3 budbreak and flowering can happen a week earlier when grafted onto Bounty compared to Bruno. This has financial implications for those growers whose fruit is early enough to make the first shipment of fruit to market. Bounty is less vigorous than Bruno and requires higher planting densities to speed up full canopy establishment. Growers developing new blocks can purchase rootstock plants and carry out their own grafting or buy pre-grafted plants.

Grafting is also used when there is a need to change cultivars e.g., from Hayward to Gold3, or as occurred post Psa. Grafts can be applied in different places on the vine: notch grafting (side graft); stump grafting; and sucker/rootstock grafting. There are also different techniques: kerf (chainsaw) grafting; cleft grafting; and whip and tongue grafting. In every case the aim is to line up the transport systems of both scion and rootstock so that there is continuous transport of water and nutrients from the roots to the leaves, and carbohydrate from the leaves to the roots. This is easier to achieve before there is extensive sap flow, the pressure of which can be enough to dislodge grafts.

Right:
Successfully grafted kiwifruit vines. Notch grafted (left), Stump grafted (centre) and Sucker grafted (right)

Mid-winter is the best time to begin grafting and should be completed by late winter. The grafting success rate declines once sap flow starts. The timing of sap flow depends upon several factors including weather conditions, soil moisture and the chosen rootstock. Sap flow normally lasts six to eight weeks.

Below:
Characteristics of various grafting methods

Kerf (chainsaw) Grafting	Cleft Grafting	Whip & Tongue Grafting
• The whole stump is not split making for easier wound protection/vine health. • Suitable for **stump** and **notch** grafting types. • Can be used on stumps cut very close to the ground. • Section has to be cut to fit the slot. • Rootstock needs to be at least 120mm in diameter (this method is best for larger old vines).	• Suitable for all grafting types **(stump, notch and sucker).** • Difficult to split the stump if cut close to the ground. • Tension of the cleft helps to hold the scion in securely. • Difficult to re-graft failures. • Size of graft wood not a factor.	• Suitable for **sucker/rootstock** grafting. • Size of graft wood not a factor. • Tension of the whip and tongue helps hold the scion wood securely.
		

Right:
Looking down on a kiwifruit stump where the canopy has been cut off and two short pieces of budwood (scion) cleft grafted on

Summer grafting is possible, but sap flow must be carefully managed. Summer grafting is generally not as successful as winter grafting and is usually only used when abnormal conditions exist. For example, if there was a high rate of grafting failure in winter, or high levels of Psa infection in the grafts. The earlier summer grafting is undertaken (November) the better the subsequent growth.

Post grafting care and graft hygiene are of the utmost importance when it comes to ensuring graft success. New shoot growth is vulnerable to damage from birds, leafrollers, bronze beetle, slugs, and snails, as well as diseases such as Psa. It is important to keep the base of stump free of weeds and use slug pellets around the base and on top of the stump.

Grafting wounds can be sealed with a wound protectant to prevent water from entering the graft union and will protect the graft against infection.

The links below are two videos showing the grafting methods outlined above.

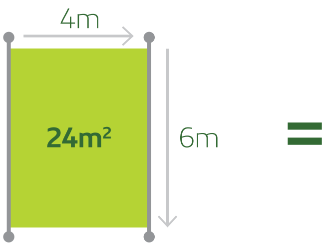
READ MORE HERE:

www.youtube.com/watch?v=4Ikpc7pv41g
www.youtube.com/watch?v=QV4AICjPUIE

2.6.1 Planting configuration

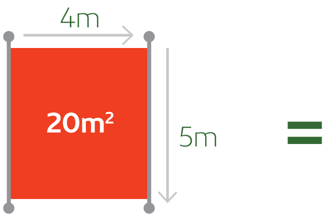
There is no standard bay size or planting configuration in the industry, and there are advantages and disadvantages to consider in both. Ensuring an optimum ratio of male to female plants it crucial, as the closer a female flower is to a male flower the more likely it is to achieve full pollination.

Row spacing around the world ranges from 3-6m, with 3.5-4.5m being the most common in NZ. Post spacing refers to the distance between posts within a row, with a bay being defined by the 4 posts in each corner. Vine spacing refers to the distance between vines within a row, which may or may not be the same as the post spacing. Sometimes vine density is increased to speed up canopy establishment – one vine between posts is "single planting" while two is "double planting". Bay size cannot be changed once the orchard is established but planting density can be altered later by adding or removing plants. More plants with a smaller footprint will have more vigour in terms of vegetative growth. Excess vigour can lead to lower dry matter and will require more labour to control.



LARGER BAYS

- Reduced infrastructure inputs
- Less plants per ha
- Less vigour management
- Slower leader establishment & canopy fill rate



SMALLER BAYS

- Increased infrastructure costs
- 20% more plants
- Higher vigour management
- Faster establishment and time to production

Different kiwifruit cultivars have different ploidy (sets of chromosomes) and not every male cultivar is therefore compatible with every female cultivar. A range of male cultivars have been bred with emphasis on male characteristics such as Psa tolerance, flower numbers, pollen fertility, a long flowering period, attractiveness to bees, and low vigour. Often more than one male cultivar is planted in an orchard to ensure there is cross over of flowering times with the female throughout the whole pollination period. Generally, it is important to use males with the same or higher ploidy than the female (otherwise smaller fruit are produced).

Female Cultivar	Ploidy	Sets of Chromosomes
Red19	Diploid	2x
Hort16A	Diploid	2x
Gold3	Tetraploid	4x
Green 14	Tetraploid	4x
Hayward	Hexaploid	6x

Ploidy	Male Cultivars
2x	Bruce, CK2, CK3, Russell
4x	M33, M91, Earp (079)
6x	Chieftain, King, M36, M43, M56

The ratio of male to female plants, and how they are arranged, has implications on the amount of canopy available for growing fruit. The two main options are Strip Males or Matrix Males (also called female opposing)

F	-	F	-	F	-	F
F	M	F	M	F	M	F
F	-	F	-	F	-	F
F	M	F	M	F	M	F
F	-	F	-	F	-	F
F	M	F	M	F	M	F
F	-	F	-	F	-	F
F	M	F	M	F	M	F
F	-	F	-	F	-	F

Strip Males

Every second row is planted with only Male plants. The male plants are spaced out (alternate bays) to reduce vigour. This is most effective with narrower rows (3-4m). This configuration can be very labour efficient as the males are trained along the leader wire and do not take up much canopy space within the bay. It allows every female plant to be in close proximity to a male.

F	F	F	F	F	F	F
F	M	F	M	F	M	F
F	F	F	F	F	F	F
F	M	F	M	F	M	F
F	F	F	F	F	F	F
F	M	F	M	F	M	F
F	F	F	F	F	F	F
F	M	F	M	F	M	F
F	F	F	F	F	F	F

Matrix Males

Males are interspersed between females in every alternate row, either every second or every third bay. Ideally their footprint is kept small to reduce vigour, and male grafts can be added on to the female vines rather than planting separate plants. More labour is required to keep the opposing females from tangling in the middle of the bay, but it is an effective method in wider rows.

M	-	M	-
F	F	F	F
F	F	F	F
-	M	-	M
F	F	F	F
F	F	F	F
M	-	M	-
F	F	F	F
F	F	F	F
-	M	-	M

East-west Strip Males

This is a hybrid of the two configurations and is often used to increase the male distribution in an established orchard. Male plants are planted by the posts and trained across the pergola/agbeam rather than along the leader wire. This requires more careful management to avoid shading the female leaders.

Right:
Orchard with strip male configuration

2.7 STRINGING

Many orchardists, during the conversion or establishment stages of orchard development employ a management practice called stringing. This is when new growth from the grafted scions is grown up strings to receive maximum sunlight. This encourages apical dominance in the new cane. When the strings are lowered these new canes become the leaders; they switch to a lateral growth habit which fills the canopy area and allows growers to move into production sooner. Once the canopy has developed, some growers choose to train their vines to a low vigour system, while other growers will continue to grow canes up strings every season, effectively refreshing their canopy each year. However, canes growing up strings above the canopy receive far less spray coverage than those trained along the pergola wires, as the canopy acts as a barrier to spray reaching those canes.

Right:
Pergola kiwifruit block set up for growing up strings
(*Shane Max, Zespri OPC)*

Right:
Kiwifruit vines growing up strings

Far right:
Kiwifruit block set up for growing up strings
(*Shane Max, Zespri OPC)*

" Once the canopy has developed, some growers choose to train their vines to a low vigour system, while other growers will continue to grow canes up strings every season. "