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ORCHARD MANAGEMENT GUIDE

Pride in our product

AVOCO Orchard Management Guide

Version 1.0

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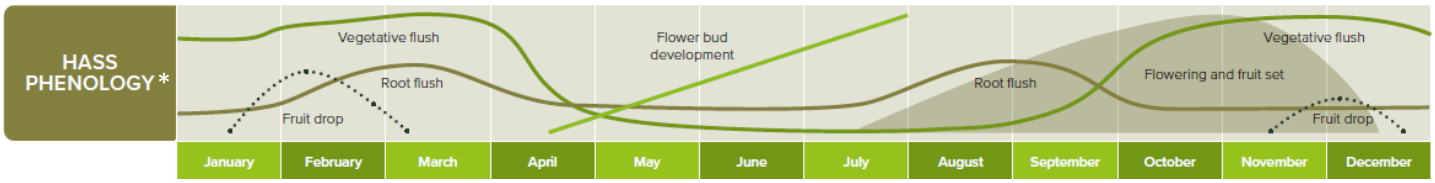
Phenology

Phenology refers to the seasonal timing of plant growth stages. The phenology each season depends on a number of factors including tree age, tree resources, tree management and climate.



Month	Plant growth stages	Tree Management Focus	Nutrition Focus
June **July**	Flower bud development		pH management (Lime)
August **September**	Increased root flush, flower bud development	Secondary injection	Foliar Boron Zinc Banding / Mounds Nitrogen Boron
October **November**	Open flowers, pollination/fruit-set and spring vegetative flush.	Flower/fruitlet pruning Follow-up structural prune. Mulch	Calcium for developing fruitlets Potassium Nitrogen
December **January**	Early fruit development period, fruitlet abortion and summer flush.	Irrigation / Water Management	Boron Potassium Nitrogen
February **March**	Early fruit development period, fruit drop and late summer flush.	Primary injection Irrigation / Water Management	Zinc Banding / Mounds Potassium Nitrogen
April **May**	Late shoot flush and increased root flush.	Main structural prune Soil and leaf sampling	Nitrogen Phosphorous

**Months are an indication only. Phenological events may shift in timing due to climatic effects.*

Preparation and Planting

For variety information, see section Varieties and Rootstocks *on page 35*

For polleniser information, see section Pollenisers *on page 37*

For shelterbelt information, see section Orchard Shelter *on page 9*

ORCHARD LAYOUT

Orchards should be planted in blocks. The size of the block depends on the contour of the land, soil type and variation, management, and wind exposure. Exposed orchards should have small block sizes of 1 ha or less, with high boundary shelter to the south and west. The ideal block size is a rectangle 50-80m wide (E-W) x 100-120 m long (N-S).

Trees should be planted in rows, orientated North-South. The spacing between rows should be at least 7 m, and the spacing between trees within a row should be at least 4 m. There should be at least 7 m between the edge trees and the block shelterbelt. 8 x 4 m is a commonly used spacing (312 trees / ha).

SOIL / BLOCK PREPARATION

Avocado roots are sensitive – adequate soil structure and drainage are key to growing healthy trees.

Pans in the soil and compacted soils can be broken up by 'ripping' prior to planting.

If the block does not have good drainage or has a shallow water table, trees should be planted on humps. Humps are formed by moving the topsoil from between planting rows onto the planting rows in order to create a mounded hump. The humps are usually 30 – 60 cm from the bottom of the hollow. The top of the hump should be flattened as pointed tops usually erode faster.

Figure 1: Humps and Hollows for a new planting.

PURCHASING TREES

Only plant trees with clonal rootstocks in replant situations. Trees produced under the High Health Scheme are certified to meet certain physical and health standards.

INSPECTING TREES

Trees should be inspected once they arrive from the nursery.

The main stem should be straight and adequately staked. The graft union should be 10 – 45 cm from the soil surface and smooth and healthy. Trees should be in a 6 L planter bag or container. The tree should be 60 – 150 cm high. The leaves should be glossy, green without deformity or discolouration. Branching should occur higher than 30 cm from the soil surface. The stem diameter at the soil surface should be greater than 9 mm. The tree should have hardened off flush and no less than 10 fully grown leaves.

The roots should be uniformly distributed through the bag, with a high proportion of white roots.

Trees must be free from symptoms of pest, disease or any other disorder.

Figure 2: Inspection for healthy, uniformly distributed roots.

TRANSPORTING TREES

Do not transport trees in open vehicles as wind damage can be severe - use well ventilated covered transport.

Never lift trees by the trunk – carry them by the bag.

Avocado roots are brittle and break easily. If bags are dropped, even from a short height, the resulting compression of the potting mix can cause root breakage. Handle bags carefully at all times.

STORING TREES

Growers should plant the young trees as soon as possible after purchase. Trees in the nursery get constant attention and are hardened off for planting. The longer the delay in planting, the higher the likelihood of stress occurring.

Never leave the trees in their bags exposed to direct sunlight for a long time, either in your yard or in the field prior to planting. The sun can cause severe heat buildup through the black plastic, killing roots. Also, storing trees in a shaded area for too long can result in sunburn when trees are planted into direct sunlight.

PLANTING TREES

- Dig a hole deeper and wider than the tree bag. This can be done with a shovel or with an auger (if using an auger, ensure the sides are not compacted).
- Saturate the potting mix of the tree (in its bag) with a solution of 2.5 mL of 40% potassium phosphonate per litre of water.
- Place the tree into the hole to check the depth – the potting mix in the planter bag should be 1-2 cm above the level of the surrounding soil.
- Carefully remove the planting bag - make a small incision and then tear the plastic away by hand.
- Position the tree in the hole such that the leafiest side is facing North.
- Fill the space between the potting mix and the hole with topsoil.
- Apply gypsum at 20g per square meter around the trees after planting.
- Soak the surrounding soil (to a distance of at least 40 cm from the potting mix) immediately after planting.

SHELTERING THE TREE

Windbreak shelters surrounding young trees provide a sheltered microclimate for the young tree to develop in. Use tall (1 – 1.5 m) 50 mm stakes spaced in 1 – 1.25 m squares and wrap windbreak around the stakes. Shelters should remain around the tree for at least one season.

Figure 3: Young trees in windbreak shelters (covers for frost)

SUPPORTING THE TREE

Supporting the avocado tree from excessive movement during early establishment is important as young avocado roots are brittle and any movement may break them, delaying the establishment of the roots into the surrounding soil. In the early planting and establishment phase a stake is usually used to hold the tree in place. Alternatively, the tree can be tied to the four stakes that support the individual shelter. There are various methods for staking trees that may differ in execution but provide the same results.

Key aspects to staking:

- Ensure the stake is located outside the root ball.
- The stake should be adequate distance that rubbing will not occur if the tree moves slightly.
- The tie securing the tree to the stake needs to stretch or grow so as not to girdle the trunk.
- Some movement is necessary to encourage the trunk to strengthen and stabilize the root system.

Figure 4: Staked young tree

Young Tree Management

FROST PROTECTION

During winter, secure frost cloth over the top of the young tree's windbreak shelter.

SUNBURN PROTECTION

Tree trunks can be painted to prevent sunburn. A common painting formula is 50% diluted, white, acrylic, water soluble, outdoor paint. This solution can be applied with a knapsack sprayer or directly with a paintbrush.

MULCH

Apply a 10 – 15 cm layer of coarse mulch at planting and annually in Spring from 10 cm from the trunk to the edge of the windbreak shelter.

IRRIGATION

Young plants are particularly sensitive to moisture levels – both insufficient and excess water can cause the roots to become compromised and the canopy to wilt. Potting mix material can dry out quicker than the surrounding soil.

Irrigate in large, infrequent events rather than small, frequent events. This allows the soil to dry out sufficiently between irrigation events.

Sprinkler heads should have a throw range which matches the tree size.

15 cm tensiometers can be used to indicate when to irrigate. Common thresholds used are:

- 20-25 kPa on sandy soils
- 30 kPa on loam soils
- 50 kPa on clay soils

As a guide, young avocado trees require approximately the equivalent of 6-11 mm of rainfall per week.

WEEDING

Hand weed the area within the windbreak shelter. Herbicides should not be used inside the shelters at any stage. Non-residual herbicides can be used outside the shelters if needed.

NUTRITION

Once the tree has been planted, it is important to implement a nutritional plan. Young trees can usually be fertilised with an NPK mix for the first few seasons until they start bearing. Other elements may need to be applied if they are at low rates in the soil, as identified by a soil test.

Base nutrient guideline for young trees

Tree Age	Drip Area (m)	N (g)	P (g)	K (g)
1	0.5	42	21	75
2	1.5	84	42	150
3	2.5	126	63	225

PRUNING

Remove shoots growing from below the graft (rootstock shoots) as close to the trunk as possible.

FLOWER AND FRUIT-SET

Remove flowers and fruit in the first year to minimise stress to the tree and encourage growth.

PEST AND DISEASE

Pests that commonly affect young trees are six spotted mites, grass grub beetles, Fullers rose weevil, bronze beetles and cicadas. Young trees should be monitored for pests and treated accordingly.

Phytophthora cinnamomi can be an issue for young trees, particularly in replant situations where pressure is high. All young trees in a replant situation, as well as those planted in new soil but showing symptoms, should be sprayed every 4-6 weeks from autumn to spring with foliar potassium phosphonate. Symptoms include root dieback from the tips, a sparser canopy, small leaves, and light green or yellow leaves.

Verticillium wilt is a disease caused by the fungus *Verticillium dahlia* which results in a sudden wilting and browning of the leaves, which do not fall off.

Figure 5: Cicada damage on the stem of a young plant.

ANIMAL DAMAGE

Do not graze large herbivores around young trees - they will strip young trees of their canopy. Possums and rabbits can damage the trunks of young trees – windbreak shelters can help to prevent this, and tree tubes/sleeves can be stapled around the base of the trunk.

Orchard Shelter

Wind can cause damage to both avocado trees and fruit. Orchard shelters protect the trees and fruit from physical damage and help to improve the microclimate within a sheltered area by helping to maintain a higher temperature and humidity. Temperature can be improved by up to 3°C in a sheltered zone.

Shelter can be in the form of shelter trees, or artificial shelterbelts. Shelter trees are inexpensive and effective; however they should ideally be planted years in advance of an orchard. Artificial shelterbelts are expensive and remain at the height installed, however they are effective immediately.

For exposed orchards:

- Ideal block size is a rectangle 70-80m wide (E-W) x 100-120m long (N-S).
- Shelter should be approximately 10-12m high.

Figure 6: Cryptomeria shelterbelt in an orchard

HEIGHT

The height of the shelterbelt determines the distance sheltered by the shelterbelt. If the height of the shelter is H, the distance of the sheltered zone will be 8 x H. For example, a 10m high shelter will provide a sheltered zone 80m downwind of the shelter. Allow boundary shelter on the south and west sides to grow as high as possible.

DENSITY

The density of the shelter has the greatest influence on wind speed, orchard humidity and temperature. The denser the shelter, the higher the increase in temperature in the sheltered zone. Orchards exposed to cold dry winds during flowering should favor dense shelter tree varieties such as Cryptomeria. Less dense shelter reduces turbulence and the physical impacts of storm winds, but does not insulate an orchard from cold, dry spring winds. Density can be improved by planting a double row. This is especially recommended for pines planted as boundary shelter. When establishing dense shelter rows across air drainage lines, care should be taken to prune main stems to 0.5-1m from the ground to allow cold air to drain out of an orchard.

BLOCK DESIGN

Exposed orchards should have small block sizes of 1ha or less. The ideal block size is a rectangle 50-80m wide (E-W) x 100-120m long (N-S). Allow for a headland of 10m between shelter row and first row of tree.

TRIMMING

Depending on the species, shelterbelts should be trimmed every 1-2 years. Trim carefully so as not to remove 'green' canopy. Some species (including pines) will not regenerate a side canopy if trimmed too aggressively.

As shelters grow, their roots can extend into the avocado block and compete for water and nutrients. One side of a shelterbelt can be root pruned approximately every 5 years.

SPECIES

CRYPTOMERIA JAPONICA (JAPANESE CEDAR)

This is one of the preferred shelter species, as it is dense, long-living and easily maintained. The young trees are extremely sensitive to wind and to glyphosate. Cryptomeria is a host plant for greenhouse thrips, a pest of avocados.

Guidelines for establishing a Cryptomeria shelter:

- If on an exposed site, erect a 1.8m high shade cloth stop on the W-side of the tree row (stapled to a basic fence-line).
- Ensure that you source large, field-grown trees from a reputable nursery.
- Plant trees 2 m apart in the row, in early July.
- Plant the trees without any amendments (fertiliser, compost, sheep pellets, etc.).

Care of newly planted Cryptomeria trees:

- Keep the tree row free of weeds by hand weeding initially (only use glyphosate once the tree is in its third year or more, and the bark is tough and woody).
- Keep the trees well-watered.
- From their third year, begin manual pruning of the trees and carefully apply small quantities of composite fertiliser.

PINUS RADIATA (RADIATA PINE)

One of the preferred shelter species, pine trees provide a dense, easily established, fast-growing and hardy shelter. They have to be regularly trimmed and topped in order to maintain an effective barrier. It is possible to allow pines to grow un-topped on the south and west boundaries. Trees should always be side-trimmed, even if allowed to grow tall, as this will promote a dense side-canopy. Pines respond very well to irrigation and fertilising, especially on sandy ground.

CASUARINA CUNNINGHAMIANA (AUSTRALIAN SHE-OAK)

A hardy, moderately fast-growing species, which provides a 'filtering' barrier. This species grows in a wide range of soil conditions. Care should be taken not to trim this shelter too heavily and to promote as dense a canopy as possible.

ARTIFICIAL SHELTER

Artificial shelter is used in certain situations where shelter is needed immediately and where orchards are productive enough to justify the extra cost.

Advantages:

- Can be erected immediately
- Do not take up a lot of space
- Maintenance free

Disadvantages:

- Expensive
- Do not last as long as natural shelter
- Height is limited and so provides a limited effect, especially on mature orchards
- Density is limited so microclimate effect is limited (i.e. the insulating effect is less than for some natural shelter species).

Figure 7: Artificial shelter used to establish young trees.

Irrigation and Water Management

For frost protection irrigation, see section Severe Weather Events *on page 38*

Irrigation is recommended during the dryer periods of the year to reduce tree stress, reduce fruit drop and improve fruit size. In the Far North region, irrigation is essential.

Figure 8: Sprinkler in an avocado orchard.

SETUP

Irrigation should be a sprinkler system, with 1 or more sprinklers (Figure 8) per tree with a radius that allows even water coverage over as much of the area from the trunk to the dripline of each tree as possible.

Tensiometers (Figure 9) or electronic probes for measuring soil moisture should be stationed on a tree in each area of the orchard with differing soil moisture factors. They should be positioned halfway between the trunk and the dripline of a tree, and within the sprinkler area.

MAINTENANCE

An annual check of all irrigation components should be undertaken 4-6 weeks prior to when irrigation is likely to be needed. A visual inspection of lines and sprinkler heads should be undertaken during each irrigation event.

Tensiometers also need to be well maintained, serviced regularly and have good contact with the soil they are installed in.

SCHEDULING

The amount of water an avocado tree uses depends on a range of factors including: the location of the orchard and tree, the size of the canopy, environmental conditions, the time of the year and the crop load. Calculating the amount of water being applied and monitoring the soil moisture status can help to inform irrigation decisions.

As a guide, young avocado trees require approximately the equivalent of 6-11 mm and mature trees 15-30 mm of rainfall per week through summer.

$$Rainfall\ equivelant = \frac{number\ of\ sprinklers\ x\ flowrate\ (liters\ per\ hour)}{wetted\ area}$$

$$wetted\ area = \pi\ x\ radius^2$$

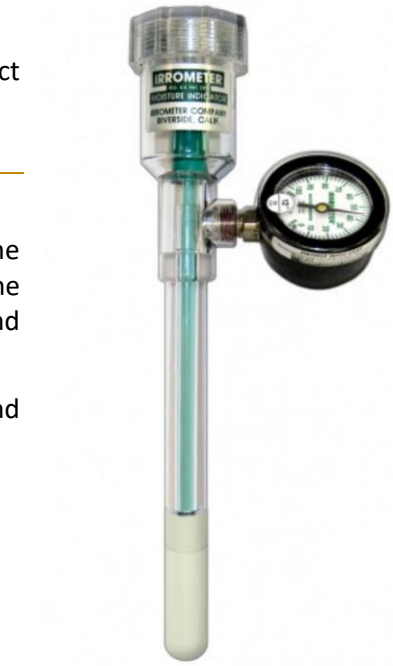


Figure 9: Irrometer Tensiometer

Use tensiometers / irrometers to monitor soil moisture status. Tensiometers measure the tension a tree needs to apply to extract water from the soil and provide a measure on how hard a tree is having to work. Common thresholds to start irrigation with tensiometers are:

- 20-25 kPa in the sandy soils such as those found in the Far North
- 50 kPa in clay soils such as those found in the Mid North
- 30 kPa in loam soils such as those found in the Bay of Plenty.

Mature avocados should be irrigated until the soil moisture is sufficient, and then allowed a drying period before irrigating again (rather than a little-and-often approach).

Canopy Management / Pruning

STRUCTURAL PRUNING

Structural pruning should be completed annually, to a canopy density of 60.

Pruning to maximize light interception needs to be a priority of any pruning or canopy management strategy - fruit will set where there is adequate light intensity.

A main structural prune should occur in Autumn, with a follow-up prune in Spring (in conjunction with flower pruning).

PRUNING PRIORITIES

1. Remove dead, diseased or damaged branches.
2. Remove poorly structured wood (e.g. inclusions, crossed over limbs, sweepers which touch the ground, watershoots).
3. Reduce height – tree height should be no more than 70% of the row width.
4. Improve access (equipment, picker and spray access). Remove limbs in the way of machinery access and create gaps in the canopy to improve spray coverage and the efficiency of picking.
5. Open the north-facing side of the tree – remove tallest branches and those which have just carried a heavy crop.
6. Reduce competitive growth in the canopy. Select 3-6 leaders from the remaining limbs with ample light and space around each. Create space around the selected leaders by pruning out secondary branches. Aim for a canopy density score of 60.

FOLLOW-UP FROM PRUNING

Pruned wood should be chipped and left under trees as a mulch. Light wood and foliage can be left (unchipped) under the tree to retain leaf mulch.

If structural pruning is completed in spring or summer, paint newly exposed limbs with a water-soluble white paint diluted 1:1 with water to prevent sunburn (Figure 10).

Figure 10: Sunburn on an exposed limb.

OTHER KEY PRUNING POINTS

In New Zealand conditions, tree height should be no more than 70% of the row width. This is to ensure a good amount of sunlight reaches the base of the neighboring trees.

Structural pruning should be completed annually (ideally in Autumn), to a canopy density of 60. A density score of 100 is where you cannot see through the canopy – a density score of 60 is where the canopy covers approximately 60% of your view of a tree.

Work around fruit where possible but be bold about cutting off the high and exposed fruit which will be the most blemished.

Regrowth will occur from where cuts are made, therefore cuts should be made below the desired canopy height.

If no regrowth is desired, limbs should be cut flush with the trunk they branch from. If a limb is cut off a distance from the branching point, a significant amount of regrowth will provide new productive wood.

Regrowth following pruning can be vigorous and shoot numbers numerous. Multiple shoots that emerge from a pruning point can be snapped off by hand when they are in the early stages of growth. When choosing regrowth branches to keep, select ones which are structurally sound and able to fill the available space without too much competition.

If new shoots don't receive enough light, they will shoot up very quickly and not generate many branch points capable of producing fruiting wood in the future. These rapidly extending shoots are often referred to as water shoots and add little to the productivity of a tree.

New growth can be 'tipped' by pinching or cutting out the apical buds to encourage lateral growth.

FLOWER PRUNING

Flower pruning and fruitlet removal are tools that growers can use to regulate the crop load on their trees and help reduce irregular bearing. Flower pruning re-balances the flowering load of the tree to allow resources to go into developing and maturing new vegetative flush.

FLOWER PRUNING ADVANTAGES

- Balances the flowering load with the level of new vegetative flush to ensure resources can be maintained to support the following spring's flowering.
- Reduces stress/demand on the tree
- Increases fruit size

FLOWER PRUNING GUIDELINES

Assess the tree health (Appendix 1: Ciba-Geigy Scale).

Assess whether the tree is flowering excessively by assessing the flower panicles. Indeterminate inflorescences have new vegetative growth points. Determinate inflorescences are flower panicles that lack any vegetative growth. Determinate inflorescences are generally better at setting fruit than indeterminate inflorescences, so a balance between the two is ideal (60% determinate: 40% indeterminate).

Where tree health is compromised or an excess of determinate flowering is present, flower pruning should be used to address the balance. If tree health is 5 on the Ceiba-Geigy scale, at least 50% of inflorescences should be removed. If the tree health is less than or equal to 6, 100% of the inflorescences should be removed.

Figure 11: Indeterminate (left) and determinate (right) flower panicles.

Healthy tree flower panicle removal guide

Percentage indeterminate flowering	Percentage determinate flowering	Percentage of flower panicles to remove
0%	100%	40%
10%	90%	30%
20%	80%	20%
30%	70%	10%
>40%	<60%	None

When pruning, firstly target panicles likely to set fruit in exposed areas prone to sunburn and other damage. Then, remove panicles evenly around the remainder of the canopy to achieve the recommended percentage removal.

Cuts should be made on wood at least 1.5 cm thick (Figure 12: Flower pruning cut).

Figure 12: Flower pruning cut

FRUIT THINNING

Fruit thinning is a tool used to reduce stress on sick trees and to reduce the crop of overloaded healthy trees in order to maintain health and resources, reduce alternate bearing, and increase fruit size. The earlier fruit removal is done, the better the response.

For sick trees, if tree health is 5 on the Ciba-Geigy scale, at least 50% of fruit should be removed. If the tree health is less than or equal to 6, 100% of the fruit should be removed.

If healthy trees are carrying an excessive crop load (where fruit is hanging throughout the canopy in bunches of >5 fruit), fruit should also be removed. Firstly, target fruit set in exposed areas prone to sunburn and other damage, and fruit hanging in large bunches.

Figure 13: Excessive fruit-set on a healthy tree before (left) and after (right) pruning.

Phytophthora / Root Rot

DIAGRAM COURTESY K PEGG

Phytophthora cinnamomi is a species of water mold which infects avocado tree roots and causes the feeder roots to rot.

Initial symptoms include feeder root dieback from the tips, small fruit size and a reduction in production. Subsequent symptoms are more visible and include small leaves, sparser canopy, yellow to light green leaf colour. In severe cases, trees die.

Phytophthora cinnamomi is prevalent in New Zealand soils, and a holistic management strategy for *Pc* should be implemented on all orchards.

PLANTING

Plant only disease-free trees on well drained soils. Drainage can be modified by mounding, ripping or addition of sub-soil and surface drains.

Plant only clonal varieties tolerant of *Phytophthora cinnamomi* in replant situations.

Saturate the potting mix of the tree (in its bag) with a solution of 2.5 mL of 40% potassium phosphonate per litre of water.

Apply gypsum or lime at 20g per square meter around the trees after planting.

Apply a coarse mulch 10-15 cm in depth after planting 10 cm from the stem to the edge of the individual tree shelter or at least 0.5 m from the trunk.

YOUNG TREES

All young trees in a replant situation, as well as those planted in new soil but showing symptoms, should be sprayed every 4-6 weeks from autumn to spring with foliar potassium phosphonate.

Be careful not to over-irrigate trees.

Mulch trees annually in late spring.

MATURE TREES

Be careful not to over-irrigate trees - reduce the sprinkler output on sick trees.

Mulch trees annually in spring.

Trees with a trunk diameter >7 cm should be injected annually with potassium phosphonate.

Inject trees with potassium phosphonate using low pressure syringes. Timing of injection is very important, and it should be done when the leaf flush has hardened off and roots are actively growing or present in large numbers (there is a natural root dieback at flowering).

- For healthy trees, inject once in autumn (Feb to April) at 20%
- For sick trees, inject in autumn and again in late winter at 10-20%

Use at least one syringe containing 20ml of solution per metre of canopy diameter, evenly spaced around the trunk. Do not drill holes in the same part of the trunk year after year.

Flowers and fruitlets should be removed from sick trees - if the tree health is less than or equal to 6 (Appendix 1: Ciba-Geigy Scale), 100% of the inflorescences should be removed.

Figure 14: Tree with low pressure syringes.

Using a 40% stock solution

Concentration % w/v	10%	15%	20%
Amount of product	250 mL	375 mL	500 mL
Amount of water	750 mL	625 mL	500 mL
Total volume	1 L	1 L	1 L

Using a 60% stock solution

Concentration % w/v	10%	15%	20%
Amount of product	166 mL	250 mL	333 mL
Amount of water	834 mL	750 mL	667 mL
Total volume	1 L	1 L	1 L

Nutrition

Fertilisation of avocado trees is a critical factor in achieving successful production, good tree health and sound fruit quality. To achieve correct fertilisation, it is important to understand the nutritional levels seen within the tree, through leaf analysis, and balances within the soil, through soil analysis. The core macro-nutrients which require focus include N, P, K and Ca. Each of these macro-nutrients play a significant role in plant and fruit development and can influence tree productivity and fruit quality if not applied in correct quantities.

- Know how many units (N, P, K, Ca) you are applying per year per hectare on your orchard.
- Units of nutrients applied must be done in relation to the estimated crop load (t/ha), along with the soil and leaf analysis results.
- Do not apply fertiliser above the rate recommended by your consultant without discussing it with them first.

LEAF AND SOIL SAMPLING

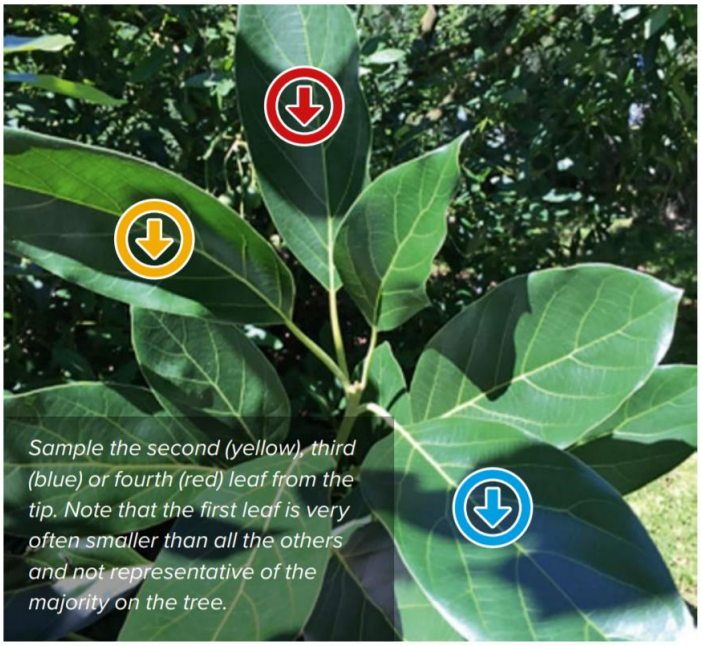
Take annual soil and leaf samples. Leaf and soil analyses are used to monitor the nutritional status of an orchard, to assist with formulating fertiliser programs and identify situations of deficiency or oversufficiency.

WHEN TO SAMPLE

Sample the leaves and soil every year to monitor trends. Take leaf samples in April/May – this is the time when elements are at their most stable. Soil samples can be taken at any time but are usually taken at the same time as the leaf samples.

HOW TO SAMPLE

Take samples from trees/blocks of the same age, on the same rootstock and growing in similar soil conditions.



Leaf sampling – select leaves at about shoulder height, from trees that are representative of those in the block. Pick the second, third, fourth or fifth leaf (blade + petiole) from summer flush branches that are not actively flushing, and not carrying any fruit. The leaves should be mature, fully expanded and representative of the average leaves on the tree. Sample from both the sunny and shaded sides of the trees. The final sample should consist of around 50 leaves. If the leaves are damp at the time of sampling, dry them before placing in a plastic bag for dispatch to the laboratory.

Soil sampling – Mulch and other organic material should be swept to one side before taking the sample. Do not sample directly into any soil where there are visible fertiliser residues left on the soil surface. Use a corer or extract a profile of soil to a depth of 15cm from halfway between the trunk and the dripline of the tree. Each core is known as a 'sub-sample' – mix the sub-samples together thoroughly before placing a blended 500 g sample in the sample bag. The more sub-samples that are taken, the more representative the final sample will be.

Table 1: Target Soil and Leaf Nutrient Levels

Target Soil Nutrient Levels

pH	H_20	5.8 – 6.5
P	Olsen	11 – 29
K	mg/kg	200 – 400
Ca	mg/kg	1000 - 3000
Mg	mg/kg	100 - 400
Na	mg/kg	0 – 90
Zn (Melich 3)	mg/kg	10 - 50
B (Melich 3)	mg/kg	4 - 6
K	% of cation ratio	4 – 8
Ca	% of cation ratio	60 – 75
Mg	% of cation ratio	15 – 20
Na	% of cation ratio	0 - 2

Target Leaf Nutrient Levels

N	%	2.4 – 2.6
P	%	0.08 – 0.15
K	%	0.75 – 1.15
Ca	%	1.2 – 2.0
Mg	mg/kg	0.4 – 0.8
S	mg/kg	0.2 – 0.6
Zn	mg/kg	25 – 100
Mn	mg/kg	50 – 250
Fe	mg/kg	50 – 150
B	mg/kg	30 - 70
Cl	mg/kg	<0.25
Cu	mg/kg	10

EFFECTIVE AND EFFICIENT FERTILISATION

Efficient and effective management practices which support increased productivity and reduced input costs can be achieved if focus is given to the critical aspects of production.

To be efficient in fertilization, identify how much the tree needs of each element (N, P, K, Ca, Mg, Zn, B) in accordance with what the tree is producing (crop load/estimate) versus what the tree has available (identified through the soil/leaf analysis results). An estimate of the elements removed by the crop can be calculated by multiplying your orchard's crop load in tons per hectare by the kg removed per ton found in Table 3 (West et al, 2022). Accurately fertilise and apply only what is needed in order to reduce waste and minimize the risk of compromising post-harvest fruit quality. Application amounts of N, P and K should be within the ranges in Table 2.

To be effective in fertilization, ensure each of the specific elements is applied at the correct phenological event (Figure 15; Phenology, Page 3).

Table 2: Application rates for the crop load on your trees (N, P, K)

kg / ha	**5 T**	**10 T**	**15 T**	**20 T**	**25 T**	**30 T**
N	10 - 60	30 - 80	50 - 100	70 - 120	90 - 140	110 - 160
P	0-5	0-10	0-15	0-20	0-25	0-30
K	20-40	40 - 80	60 - 120	80 - 160	100 - 200	120-240

Table 3: Average Nutrient Removal NZ (West et al, 2022)

Nutrient	kg removed per 10 T/ha	kg removed per ton
N	27.1	2.71
P	4.1	0.41
K	44.5	4.45
Ca	1	0.1
Mg	2.7	0.27
S	3.5	0.35
Zn	0.060	0.006
Mn	0.018	0.0018
Fe	0.063	0.0063
B	0.226	0.0226
Cu	0.028	0.0028

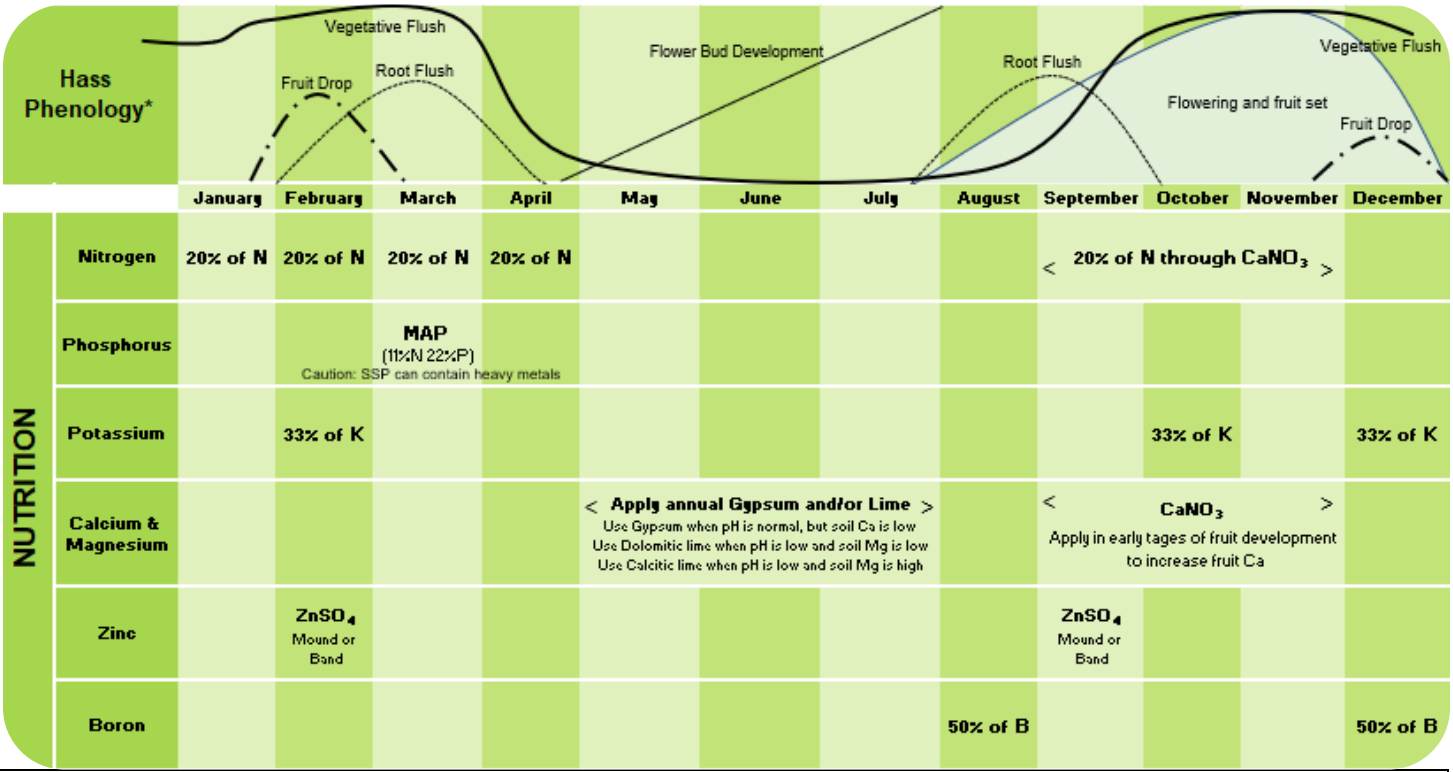
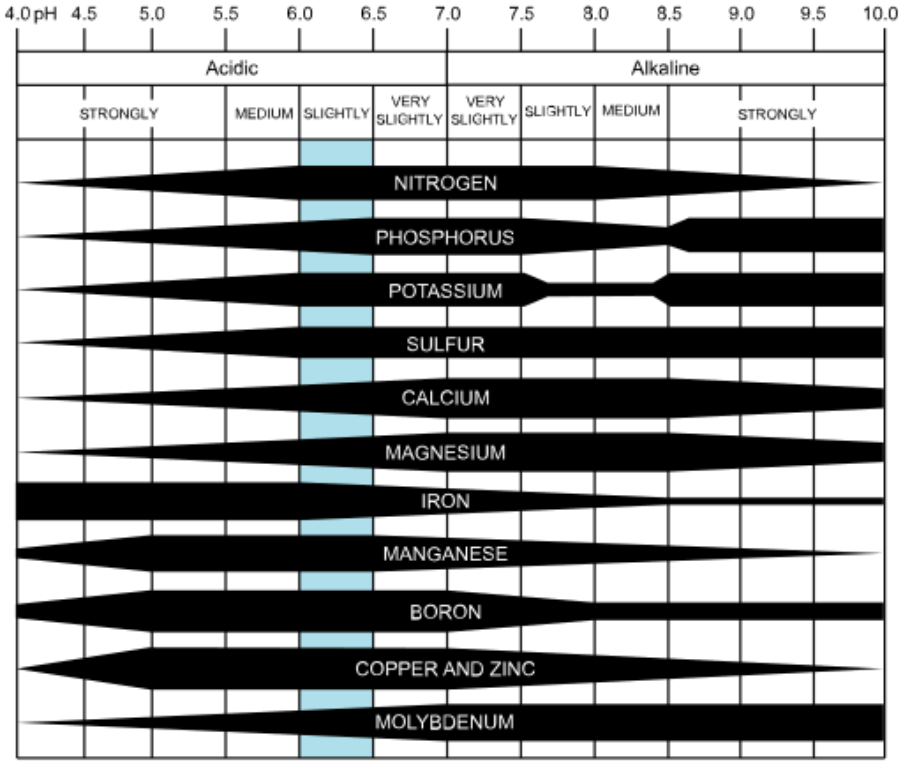


Figure 15: Hass phenology and fertiliser timing

**Months are an indication only. Phenological events may shift in timing due to climatic effects.*

SOIL PH

Soil pH has an impact on the availability of nutrients.



Calcium can be used to adjust the pH of the soil if low (Ideal range 5.8 – 6.5)

- Calcitic lime : Ca only and adjusts pH
- Dolomitic lime : Ca + Mg and adjusts pH
- Gypsum : Ca only and does not influence pH

NUTRIENT INTERACTIONS

Elements in the soil interact with one another (Appendix 2: Mulders Chart of soil nutrient interactions).

NITROGEN

Nitrogen is an important macro-nutrient required for vegetative growth and maintaining tree health; however, it must be noted that this can be at the detriment to fruit quality.

- Nitrogen is the key element for vegetative growth.
- Referred to as the 'manipulator element'.
- Increases vegetative growth at the expense of reproductive growth (temporarily).
- Good leaf cover favors energy production for fruit development.
- Split applications of fertiliser biased post fruitset.
- Too much N applied at the wrong time can induce fruit drop.
- Deficiency seen as pale green or yellow leaves.

Do not apply greater than 160 units of N/ha/year. This is in order to not exceed the crop removal factor in line with the crop load and considering available N from soil organic matter, etc.

Nitrogen has an influence on the movements of other nutrients, such as calcium; if a high amount of nitrogen is applied in the incorrect time of the tree's phenology, it can create a strong vegetative flush which acts as a strong 'sink' and will pull the available calcium into the leaf, at the detriment of the fruit. This creates a dilution effect of calcium within the fruit during development and will lead to a higher potential for weak cell wall and cell membrane structure. The result is a higher probability for cell collapse within the skin and flesh when exposed to the cold chain and will limit shelf life of the fruit. Symptoms will exhibit as chilling injury on the skin as cells collapse and blacken due to stress under cooling. Internally, the flesh may develop grey pulp which is due to polyphenol oxidase leaking from cell membranes and oxidizing. This becomes more prevalent as fruit age increases post-harvest.

PHOSPHOROUS

If levels of P are sufficient, do not apply.

- Important for development of roots, flowers and fruit due to the involvement in cell division.
- If deficient seen as red/purple leaves, small trees and misshaped fruit
- Avocados are naturally low P scavengers.
- Usually a single application is sufficient. Many orchards will never require a P application.
- Timing of application is during root flush to help uptake into tree.
- Very slow-moving element in soil profile and in tree.
- P sources have risk of heavy metal contamination (rock phosphate).
- High P levels can create post-harvest quality issues.

POTASSIUM

- Important for fruit development / size.
- Application after fruit set.
- Apply in 3 split applications biased towards early fruit set.
- Important not to use KCl as avocados are very sensitive to Cl and salinity.
- Best products to use are Potassium Sulphate (K_2SO_4) or Potassium Nitrate (KNO_3).

CALCIUM

Available calcium is required to ensure cell wall development and integrity, so application of calcium nitrate should be applied at early fruit set and through early fruit development to ensure uptake into fruit whist it is a strong 'sink'. Application of calcium nitrate once the fruit is in its plateau stage of development would not see the same effect.

- Calcium is very important for the cell wall strength, fruit size and post-harvest quality.
- Application should be done just prior to or at very early fruit set.
- Shown to help with suppression of Phytophthora root rot.
- Calcium nitrate is key to ensuring Ca is readily taken up/available to the tree during flowering and early fruit set.

MAGNESIUM

- Important component in chlorophyll molecule, therefore photosynthesis.
- Role in enzymes to stimulate normal growth.
- Deficiency seen as interveinal chlorosis.
- Not commonly an issue but soils high in calcium could create issues.
- Single application of MgSO4 usually sufficient to get back into balance.

BORON

- Important for flower development and fruit set.
- Very narrow optimal range. Becomes toxic or deficient very easily.
- Deficiency symptoms include small holes in leaves (Figure 16).
- Common products are organibor, solubor and boronate.
- Can include in foliar sprays during flower as ‘short term fix’.

Figure 16: Boron deficiency 'shotholes'

ZINC

- Important for shoot and leaf development.
- Deficiency symptoms include stumpy growth and curled leaves.
- Very difficult to achieve uptake into trees.
- Heavy interaction with P and Ca (need at least a 2-month gap in applications).
- Apply Zinc Sulphate in mounds / banded around drip zone.
- Can include a chelated Zn in foliar sprays to attempt short term uptake.

Heavy Metals

CADMIUM

Cadmium can be present in the soil naturally, from past fertiliser applications, and from fertilisers applied for avocado growing. Cadmium is found as an impurity in phosphate fertilisers. As avocados are low phosphate foragers, the application of phosphorus is often not required, especially if levels are sufficient.

Total cadmium in soil can be tested during your annual soil test.

- If phosphorus levels are sufficient, do not apply fertilisers containing P.
- Add a total Cadmium test to your annual soil test.
- Ensure zinc levels are sufficient.
- Ensure your pH is in range.

If elevated levels of Cadmium are present in the soil, there are some actions which can be taken to reduce the uptake into fruit. Soil type, organic matter, zinc uptake and pH are known to affect cadmium uptake.

Factor	Details	Actions to take
pH	In general, as soil pH increases, Cd plant uptake decreases.	Aim for pH > 6
Zinc	Cadmium competes with Zinc for plant uptake and translocation. Alleviating Zn deficiencies or adding Zn to agricultural soils can result in reduced Cd uptake.	Ensure zinc is sufficient. If not, apply zinc in mounds or bands.
Organic Matter	In general, as soil Organic Matter increases, plant uptake of cadmium decreases. This is due to increased soil adsorption of Cd, amongst other factors.	Apply mulch or compost.

Soil type – cadmium is generally more available to plants in sandy soils, and less available in clay soils.

Pests

- Follow NZ Avocado's AvoGreen Monitoring Programme for pest identification and monitoring.
- Follow the AVOCO Pest Control Options document for pest control.

The main pests of concern for avocado fruit and mature trees in New Zealand are Leafroller, Greenhouse Thrips and Six Spotted Mite. Armoured scale and Long-tailed Mealybug are minor pests of market access concern. Fullers Rose Weevil and Flower Thrips are not considered pests on mature orchards, however they are also of market access concern.

LEAFROLLER

Leafrollers (LR) includes a range of species:

- brown-headed leafroller *Ctenopseustis obliquana* and *Ctenopseustis herana*
- black-lyre leafroller *Cnephasia jactatana*
- green-headed leafroller *Planotortrix excessana* and *Planotortrix octo*
- light brown apple moth *Epiphyas postvittana*

Both leafroller caterpillars and eggs are quarantine pests, however only caterpillars damage fruit and leaves, as only these feed by chewing. Caterpillar feeding results in obvious fruit scarring in the form of shallow oval gouges.

Figure 17: Leafroller caterpillar and damage to fruit

GREENHOUSE THRIPS (GHT)

Heliothrips haemorrhoidalis - Feeding by both larval and adult greenhouse thrips causes severe damage to avocado leaves and fruit resulting in fruit being downgraded or rejected for export. Damage is in the form of fruit scarring with/without tarry residue.

Figure 18: Thrips damage and juvenile thrips

SIX SPOTTED MITE (SSM)

Eotetranychus sexmaculatus - Six spotted mite primarily feed on the underside of leaves, concentrating its activity adjacent to leaf veins. Infestation can cause leaf drop and impact the health of the canopy and tree. Control requires targeted chemical, cultural or biological measures. Temperature extremes (hot or cold) as well as a range of natural enemies often maintain these mite species at low levels. Six spotted mite is not associated with fruit.

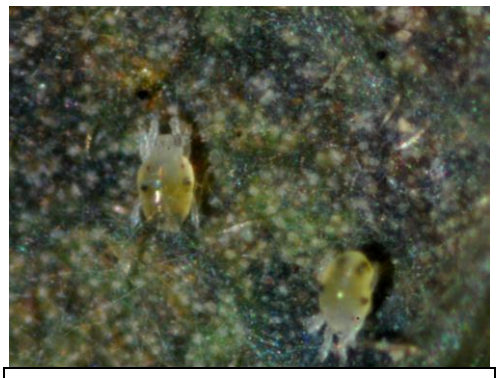


Figure 19: Adult Six Spotted Mites

MAMMALIAN PESTS

Rats and possums can bite or chew avocados. Damage is often seen on the neck of the avocado, close to the stem. Management of mammalian pests is often required on orchard.

Diseases

For Phytophthora, see section Phytophthora / Root Rot *on page 15.*

VERTICILLIUM WILT

Verticillium wilt is a disease caused by the fungus *Verticillium dahlia.* Soil-born *Verticillium* enters via the roots and affects the water-conducting tissues in the trunk and branches. The visual symptoms are sudden browning and wilting of the canopy with the leaves remaining on the tree. Pink/brown staining can often be seen in the vascular strands of affected branches. Parts of a tree or the whole tree can be affected.

Verticillium infection can arise through planting avocados on land previously occupied by a susceptible crop, replanting after removal of diseased trees, or spreading via contaminated pruning tools.

If trees are affected by verticillium wilt, remove all infected tissue back to a point where new, unaffected growth is visible. Remove infected branches from the orchard, and burn. Disinfect pruning tools.

If verticillium is present within the orchard, ensure to regularly disinfect pruning tools and avoid pruning in wet conditions.

Figure 20: Tree with *Verticillium* wilt.

OTHER FUNGAL DISEASES

Other fungal diseases (including Colletotrichum) can cause branch dieback. Warm and wet conditions are conducive to infection. Young and stressed trees are particularly susceptible.

Management practices include:

- Remove tree stresses.
    - Prune any flowers off.
    - Ensure soil moisture management is sufficient.
    - Protect trees from wind.
- Apply fungicide to protect the remaining healthy material.
- Remove infected tissue and deadwood by trimming out any affected plant parts. Ensure to sterilize cutting tools between trees.

Mulch

Mulches improve soil organic matter, microbial populations and oxygen levels. They can also help to regulate soil temperature, maintain a good soil moisture and suppress weed growth.

Mulch trees with a coarse mulch annually in spring (5-10 cm depth, from the trunk to the dripline).

It is important to ensure that the mulch layer is not placed against the base of the trunk as this can create collar rot.

The best mulches have a carbon: nitrogen ratio of between 25:1 and 100:1. Composted coarse wood chip is a good mulch, such as the pruned limbs from your trees.

Weed Management

See also section Mulch *on page 26.*

Weeds compete with avocados for water and nutrients.

Mulch suppresses weed growth.

Only spray herbicides outside the dripline of avocado trees and use non-residual herbicides. Weeds within the dripline should be removed by hand or other mechanical method.

Weed mat can be used for weed management. It is more suited to orchards using fertigation as distribution of solid fertiliser can be challenging.

Fruit Set

See section Pollenisers *on page 37*

See section Flower Pruning *on page 13*

See section Nutrition *on page 17*

At least 6 honeybee hives per hectare should be in the orchard from when the flowers begin to open, spread evenly throughout the orchard in groups of 2-4 hives.

FLOWER DEVELOPMENT

In New Zealand, floral initiation occurs in late Autumn, flower bud development continues through winter and flowers begin opening in spring. In order to support floral development, it is important that trees have sufficient light, water and appropriate nutrition.

Avocado flowers open as a female, close, and open again as a male. A- and B-type avocado varieties have different flower opening patterns, and having a combination (e.g. B-Type Pollenisers for A-type Hass) increases the flowering overlap time for pollen transfer to occur.

Table 4: A- and B-type flowering patterns in ideal conditions.

	Day 1		Day 2	
Flowering type	**Morning**	**Afternoon**	**Morning**	**Afternoon**
A	Female			Male
B		Female	Male	

Temperatures affect flowering. Frost can cause damage to flower buds and flowers - severe frosts and late frosts occurring close to flowering are of the most concern. Also, temperatures below 5°C have been shown to reduce flower viability of flowers about to open or that have opened recently.

Avocado trees in New Zealand often produce a lot of flowers, however a normal fruit-set is about 0.3% of the flowers. Flower development places significant strain on the tree, so it is important to balance the tree and maintain carbohydrate reserves by pruning away excessive flower.

Figure 21: Avocado flowers open in the female (above) and male (below) phase.

POLLINISATION

Pollenisation is the transfer of pollen from the anther of a flower open in the male phase to the stigma of a flower open in the female phase. Honeybees are an important polleniser of avocados. For fruit-set, it is important to have pollinators present and active within the orchard. Hives should be brought into the orchard once the first open flowers are seen. Generally, 6-8 hives per ha spread throughout the orchard ensures that there is enough bee activity to assist in pollination. Avocado flowers are not the most attractive of food sources for bees, so it is important wherever possible not to have competing pollen sources within the immediate area. Also, make sure there is easy access to water for the bees.

Figure 22: Honeybee pollinating avocado flower

FERTILISATION

Fertilisation occurs when the pollen tube reaches the ovary. Fertilisation failure can result in cukes (a seedless, small, elongated avocado) – thought to be related to temperature.

FACTORS INFLUENCING FRUIT SET

- Temperature (prior to, during and after flowering).
- Bees – on cold, wet or windy days there is little bee activity and limited pollination.
- Flower amount.
- Pollen availability (including pollenisers).
- Water.
- Nutrients (particularly boron and calcium).

Fruit Size

Fruit size differentiation occurs mainly during the early stages of fruit development. In order to maximize fruit size, ensure there is sufficient water and resources during this period (November – March):

- Tree health – healthy roots take up nutrients more efficiently.
- Irrigation – ensure your irrigation plan is effective.
- Fertilization – potassium nutrition is particularly important.
- Flower pruning and fruit thinning early can help to increase fruit size by managing crop load and reducing competition for resources.



Harvest

HARVEST GUIDELINES

PREPARING FOR HARVEST

- Do not irrigate in the 48 hours prior to picking.
- Ensure that fruit complies with relevant spray withholding periods.
- Harvesting should be done at temperatures less than 30°C, and never above 35°C.

HARVESTING BEST PRACTICE:

- Do not harvest fruit that has fallen to the ground.
- Use specialized avocado clippers with rounded noses. Do not use extension pickers unless necessary.
- Cut all stalks to 5 mm or less.
- Pickers must keep fingernails short or wear cotton gloves.
- Minimize physical damage (cuts, scratches, abrasions) at all points.
- Do not use dropped bags when picking from elevating work platforms.
- Aim to place fruit in bags/bins/buckets rather than dropping. Do not drop avocados more than 25 cm into picking bags or when emptying from picking bags/buckets. Use the height-limiting draw cords.
- Do not overfill bags or bins.
- Place bins strategically so that pickers only walk a short distance with full bags/buckets.
- Always keep bins in the deepest shade possible whilst picking.
- Do not allow bins to stand in muddy areas or on loose metal – dirt or stone chip can be entrapped in wood runners and fall into other bins when stacked.
- Regularly check the condition of bins for sharp, potential fruit injury points.
- Remove all plant debris from picking bags and bins each time they are emptied.
- Sterilise picking equipment: at every break (at least) for clippers, and bags/bins/buckets daily, by dipping or spraying with products such as:
    - 10% Janola solution
- It is recommended that exposed fruit at tops of trees be harvested first.

Rain

Picking turgid fruit increases the risk of postharvest disorders.

- Do not pick in the rain (wait until fruit is dry to the touch or two hours after rain).
- Do not pick if more than 5 mm of rain has fallen in the last 24 hours.
- If there has been more than 50 mm of rainfall in the past 48 hours, determine whether the fruit and orchard floor is dry and conduct a roll test (Appendix 3) prior to harvesting the orchard.

Managing Picking Teams

- Be present for the duration of picking.
- Tell the picking team your requirements (including size).
- Keep all instructions clear and concise.
- Keep bins close to where the pickers are working (to reduce time and costs).
- Communicate with the team leader or representative if you have any concerns.
- Regularly check fruit in the bins for size, long stalks, clipper cuts and handling damage.

PICKED FRUIT

- Every effort must be made to deliver fruit to the Packer on the day of harvest. Harvested fruit must be delivered to the Packer within 24 hours of harvesting.
- Fruit held on orchard awaiting transportation must be held in the shade under cool conditions.
- Do not move field bins at speeds that will result in fruit being bounced around.
- Cover bins during transport.

PICKING STRATEGIES

When you receive your bin allocation for your first pick, you have to decide which method best suits your orchard to match the allocation and leave an economic amount of fruit to pick later (generally no less than 30% across all trees). Removing at least 60% of the total crop prior to the end of December is beneficial for the return crop (Zhang et al, 2020).

Weight bands for size counts

14*	368+ g	**25**	208 – 228 g
16	325 – 367 g	**28**	184 - 207 g
18	290 – 324 g	**30***	162 – 207 g
20	257 – 289 g	**32**	162 – 183 g
23	229 – 256 g	**36**	142 – 161 g
24*	208 – 256 g	**42***	123 – 141 g

**non standard count*

SIZE PICKING

Determine the size you want to pick to (often dependent on the market you are picking for). Weigh fruit until you find one that is at the smallest size you want to pick to. Ask pickers to put their thumb and forefinger around the fruit at the widest point and measure the gap using their other hand. Other methods use sizing rings that pickers can wear on a string around their necks or picking the largest fruit from bunches of fruit. Occasionally, check the pickers' fruit size as they empty the fruit into bins to make sure they are picking to the agreed size.

STRIP PICKING – TREE OR SELECTED BRANCH

Strip picking is the stripping of all the fruit on a tree or branch regardless of size. This may be done for reasons of; removing trees from the orchard, pruning on selected branches, recovering sick trees, removing fruit from exposed trees/blocks, or having only one pick on small orchards. If stripping branches for pruning, mark branches to be stripped with spray paint or tape.

SKIM PICKING

Picking the fruit on the outside of the tree without going into the tree. Generally used when exposed fruit is at risk from sun or wind. All remaining fruit should be covered by leaves and can continue sizing. Can be quicker than other methods.

EXPOSED FRUIT PICKING

Picking the fruit that has no leaf cover—pick all the fruit off these branches back to the first leaves. Getting this fruit off early before the heat of summer and before it colours gives it a greater chance of being graded as export. If exposed fruit already has some colour, removing this fruit can still be beneficial to reduce further colour and allow the remaining fruit to size.

Figure 23: Exposed fruit

COLOURED FRUIT PICKING

Coloured fruit is usually found where there is little or no leaf cover or on the northern side of a tree which is exposed to more sun. Removing this fruit early will help the remaining fruit size as the colouring will never grow out. Colours will range from yellow through to red and black.

Fruit Quality

See section Nutrition *on page 17.*

In order to maintain our position as a premium product in the market, we need to continually improve the quality and post-arrival performance of exported avocados.

Defined areas of improvement:

- Shelf life (ability of the fruit to withstand extended transit times).
- Consistency of post-arrival performance.
- Reduction in green fruit disorders (lenticel damage, fuzzy patches, discrete patches, external rots).
- Reduction in ripe fruit disorders (diffuse flesh/grey pulp, stem-end rots, body rots).

To improve the quality of New Zealand avocados, it has been identified that AVOCO needs to work both individually and collaboratively across all areas of the supply chain to review and address the elements influencing fruit quality.

Figure 24: Avocado with fuzzy patches

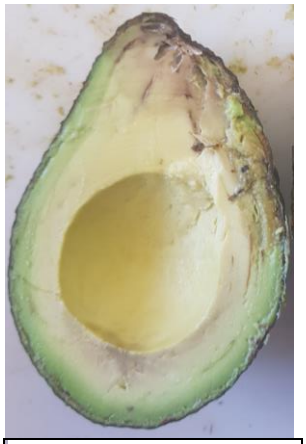


Figure 25: Avocado with stem-end rot and diffuse flesh

TREE HEALTH

- Treat your trees annually with low pressure phosphonate injections to maintain root health.
- Maintain a layer of coarse mulch from the dripline to the trunk of your trees (5-10 cm deep).
- Ensure there is adequate drainage for water.
- If using irrigation, schedule according to monitored soil moisture status. Ensure adequate drying periods between irrigation events.
- Control the six-spotted mite population on your orchard to maintain canopy health.
- Take annual leaf samples to assess any deficiencies and fertilise according to nutrient levels and crop load.

CANOPY MANAGEMENT

- Remove deadwood and mummified fruit from the canopy.
- Prune the canopy annually to a density score of less than 60. A density score of 100 is where you cannot see through the canopy – a density score of 60 is where the canopy covers approximately 60% of your view of a tree.

FUNGICIDE

- Apply a programme of 8 or more copper sprays on each crop.

NUTRITION

- Ensure calcium is available to your trees during the early fruit growth period.
- Know and keep a record of how many units of each macronutrient (N,P,K) you are applying to your orchard each season.
- Units of nutrients applied must be done in relation to the estimated crop load as well as the leaf and soil analyses results.
- Do not apply greater than 160 units of N/ha/year.

HARVEST

- Follow the AVOCO Harvest Guidelines, including;
    - Do not irrigate in the 48 hours prior to picking.
    - Do not harvest fruit in the rain or after more than 5 mm in the past 24 hours.
    - If there has been more than 50 mm of rainfall in the past 48 hours, determine whether the fruit and orchard floor is dry and conduct a roll test prior to harvesting the orchard.
    - Sterilise clippers at least at every break, and bags/bins daily.
    - Do not pick with dropped bags on elevated working platforms.
    - Ensure bins are in the deepest shade possible.
    - Minimise fruit jostling and drops at all points of harvest and during transport.

Varieties and Rootstocks

For polleniser scions, see section Pollenisers *on page 37*

Avocado scions (the fruiting part of the tree) are usually grafted onto rootstocks of a different variety. The most common scions and rootstocks are detailed below.

SCIONS

The scion is the fruiting part of the tree. Hass is the most common fruiting variety and is the only scion with export standards.

HASS

Hass is the most common commercial variety of avocado. The spreading trees can produce high yields of medium-sized ovate fruit with good post-harvest characteristics, and which change colour on ripening. As Hass is currently the only scion with export standards, it is recommended as the main variety to plant in New Zealand. The main export harvest season for New Zealand Hass is from August to February.

REED

Reed is a round green-skin variety (Figure 26) produced on upright-growing trees. The fruit are larger than Hass and mature in March-June in New Zealand, and are sold in the domestic market in some seasons.

Figure 26: Mature Reed fruit

CARMEN

Carmen is a cultivar managed by Brokaw nursery in California. Spring-set Carmen fruit appears almost identical to Hass fruit. Carmen trees often flower out of season – this out of season flower produces a large, round, smooth-skinned fruit which blackens on ripening. The season for Carmen is similar to Hass.

MALUMA

Maluma is a cultivar from South Africa, developed by Allesbeste for its low vigour and central leader growth tendency. Maluma fruit is generally larger than Hass fruit, with a 'neckier' shape, and turns black on ripening. Due to low yields in New Zealand trials and the lack of maturity standards for the variety, it is currently not recommended to plant Maluma.

ROOTSTOCKS

Avocado scions can be grafted onto seedling or clonal rootstocks. Seedling rootstocks are inherently variable, however they have the potential to produce satisfactory yields when growing conditions are good. Clonal rootstocks can overcome some of the variability and impart some benefits in yield, vigor and tolerance to disease (including *Phytopthora cinnamomi)*. Many of the imported clonal rootstocks are covered by Plant Variety Rights (PVR, similar to a patent) and purchase of these requires a non-propagation agreement and royalty payment.

ZUTANO (SEEDLING)

Zutano is the most common seedling rootstock used in New Zealand. It is currently not recommended to plant any other variety of *seedling* rootstock. As a seedling rootstock, variability in production and tolerance to environmental and disease pressure is variable. However, in virgin soils and favorable conditions Zutano rootstock trees can perform well in New Zealand. It is not recommended to plant Zutano rootstock in replant situations.

BOUNTY (CLONAL)

Bounty is a cultivar managed by The Fruit Farm Group, South Africa. It was selected for its tolerance to *P. cinnamomi*, and ability to survive in wetter soils. Bounty has performed well in New Zealand trials, including in replant situations.

DUKE 7 (CLONAL)

It is currently not recommended to plant Hass on Duke 7 rootstock.

DUSA (CLONAL)

Dusa is a cultivar managed by Westfalia, South Africa. It was selected for its tolerance to *P. cinnamomi,* and has been a popular variety since the early-mid 2000s. Dusa has performed well in New Zealand trials, including in replant situations.

LATAS (CLONAL)

Latas is a cultivar managed by Westfalia, South Africa. It was selected for its tolerance to to *P. cinnamomi*, and ability to survive waterlogged and saline conditions. Results have been mixed in New Zealand trials.

SR1 (CLONAL)

SR1 is a rootstock which was developed in New Zealand from propagation of a survivor tree. Extensive trials of this variety against others have not been undertaken.

Pollenisers

B-type flowering varieties are useful as pollenisers to improve fruit-set for A-type flowering Hass orchards. It is useful to have more than one variety of polleniser, as the flowering overlap between Hass and different polleniser varieties may vary season to season. The pollenisers below all have an upright, slender growth structure which reduces the orchard space requirement of the trees.

On most New Zealand Hass orchards, a mix of polleniser varieties should be planted throughout the block in a 1:8 ratio (11%).

ZUTANO

Zutano is the most common polleniser variety in New Zealand. It is a Mexican hybrid and produces thin-skinned shiny green fruit which is of poor eating quality.

BACON

Bacon is another common polleniser variety. It is of Mexican origin and produces thin-skinned, smooth green fruit.

ETTINGER

Ettinger is a green-skinned Mexican variety from Israel. They do not often produce fruit in New Zealand.

EDRANOL

Edranol is a variety originating from California. They do not often produce fruit in New Zealand.

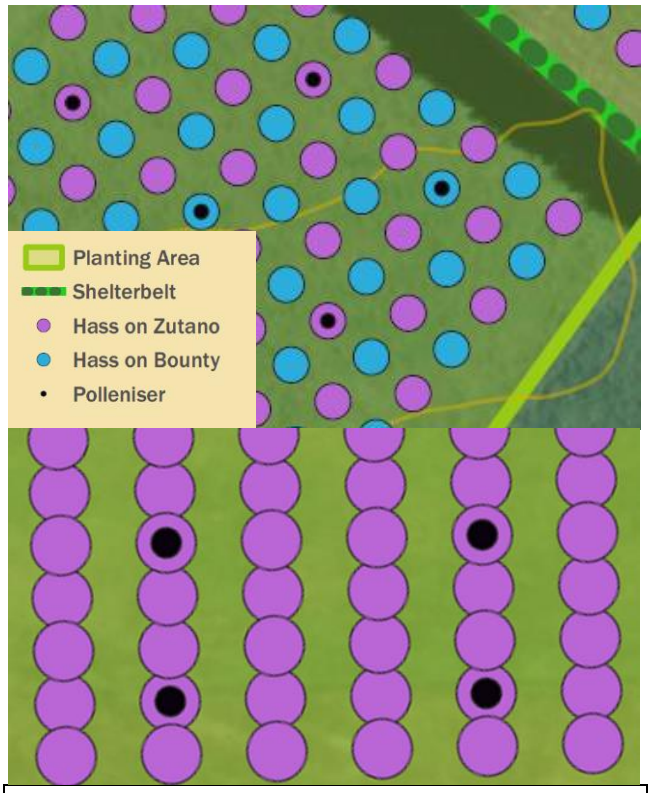


Figure 27: Example planting plans showing 1:8 ratio

Severe Weather Events

For shelterbelt information, see section Orchard Shelter *on page 9*

FROST

Frost can cause damage to flower buds, flowers, fruit and foliage. Severe frosts and late frosts occurring close to flowering are of the most concern.

There are frost protection methods available, however the effectiveness of these is limited. It is best to plant avocados in locations which do not usually experience severe or late frosts.

Frost Management Strategies

Plant resistance to Frost	Preventing ice crystal formation	Retaining heat	Adding heat	Removing cold
• Improve tree health. • Use nutrition to promote hardened-off leaves going into winter.	• Foliar sprays of copper prior to frost events. • Remove deadwood from the canopy.	• Ensure adequate shelter. • Keep the area beneath the trees free of vegetation.	• Frost fans. • Irrigation. • Overhead irrigation.	• Prune shelter and lower branches of trees to allow cold air drainage.

During clear nights, the air closest to the ground surface cools faster than the air above it, resulting in a heat inversion layer. Frost fans utilize this inversion layer by drawing warmer air down to mix with the cooler air.

Overhead irrigation is the most common form of frost protection in New Zealand avocado orchards. It relies on latent heat being released as water freezes on the outside of plant tissue, protecting it by keeping it above 0°C. Sprinklers will be set to come on when the temperature drops below a certain point, usually 2 or 4°C. The irrigation will stay on until the temperature comes above a certain threshold. They have the potential to use a significant amount of water if temperatures remain low for extended periods of time. This impacts soil moisture levels, which can be a significant issue for tree health, especially in the winter months.

WIND

Wind can cause damage to both avocado trees and fruit. If trees are blown over during a storm, they can be righted during a window of approximately two days (particularly young trees). If the trees are not able to be righted until after two days, they should be either left as they are and pruned, or removed.

For shelterbelt information, see section Orchard Shelter *on page 9*.

FLOODING

Flooding can have severe impacts on avocado trees. Trees should be planted in areas with free-draining soil and low risk of flooding. If a tree's roots are flooded for a period of two days or more, tree death may occur.

Symptoms of flood damage are a sudden wilting of the canopy, with the leaves remaining on the tree. Any fruit on the tree often becomes spongy due to a lack of water being delivered.

Soil moisture levels that are too high reduce the amount of air in the soil, leading to:

- The supply of oxygen to roots being limited, affecting their function.
- A reduction in water and nutrient uptake.
- A reduction in photosynthesis, impacting tree vigor.
- An impact on fruit sizing and maturity.
- Increase the tree's susceptibility to *Phytophthora*. Free water in the soil can also aid the spread of *Phytophthora* throughout the orchard.

Standing or pooled water are the obvious signs of waterlogging but if you have subsoils that are less pervious to water, the soil layer above can become saturated and cause damage to roots. Subsoils may also affect the flow of water, meaning areas of orchards can be affected that may not be intuitively identified by looking at the surface contour of the land.

Removing excess water from the soil as quickly as possible and creating a more aerated soil may help waterlogging. Ripping soil or digging temporary trenches may also help but these methods are often difficult to carry out in an established orchard.

Once a tree begins to wilt, the majority of damage to the root system has likely already occurred. Pruning the canopy back heavily will help reduce the amount of canopy the now limited root system is supporting, speeding the recovery of the tree (if recovery is possible).

DROUGHT

Symptoms of drought are a wilting of the canopy, with the leaves remaining on the tree. Fruit on the tree can become spongy due to a lack of water being delivered.

Soil moisture levels that are too low lead to:

- Root dieback, affecting their function and ability to provide sufficient moisture to the canopy.
- A reduction in water and nutrient uptake.
- A reduction in photosynthesis, impacting tree vigour.
- An impact on fruit sizing and maturity.

Watering trees impacted by drought can cause improvement, however it is important not to over-water trees impacted by drought as a compromised root system may not take up water efficiently and excess water applied could result in waterlogging.

Pruning the canopy back heavily can help to reduce the amount of canopy a limited root system is supporting.

HAIL

Hail can damage fruit (particularly developing fruitlets) and canopy. Spray copper after hail event to protect fresh wounds on fruit and foliage from infection.

Maturity

Avocado fruit need to be mature when they are harvested in order to ripen uniformly and ensure good eating quality. The maturity of avocados is related to the moisture content of the fruit and can be tested through the dry matter content of fruit samples.

Export Maturity Standard:

- Average dry matter content >24%
- 18 out of 20 fruit >20.8%

Local Market Maturity Standard:

- Average dry matter content >23%
- 18 out of 20 fruit >20.8%

MATURITY STANDARDS AND TESTING

Each season, fruit within a maturity area can be independently tested to determine the dry matter status of the fruit and whether it meets the requirements to be harvested for the local and/or export markets. Maturity and testing must meet the requirements of the Export Maturity Standards in the New Zealand Avocado Quality Manual.

During the season, once industry monitoring indicates that fruit within a region is meeting dry matter requirements, New Zealand Avocado will issue a blanket maturity clearance for the region. Once this is issued, there is no longer a requirement to test the dry matter of each maturity area within the region.

FACTORS INFLUENCING MATURITY

Avocados reach harvest maturity at different times during the season. Factors which influence maturity include:

- Variety - Hass in New Zealand tends to reach minimum maturity from July to November.
- Tree age - Fruit on younger trees tends to mature earlier than fruit from older trees.
- Region - Fruit in the Far North tends to mature earlier than fruit from the Bay of Plenty and Mid North.
- Season - Due to differences in the climatic conditions, maturity can be earlier or later seasonally. Seasonal differences can differ between growing regions.
- Elevation - Orchards at lower elevations tend to mature earlier than orchards in higher elevations.
- Water status - Tree water status can influence maturity, with drier conditions tending to increase maturity.

Crop Estimation

The crop estimate is a very important planning tool for growers, packhouses and exporters.

A method for crop estimation:

1. Identify areas of the orchard with similar trees (age, size, management and location).
2. Select 10% of the trees from each area (e.g. mark on a map).
3. Estimate the amount of fruit on each of the selected trees.
4. Calculate the amount of fruit in each area:

$$fruit\ in\ area = \frac{fruit\ on\ sample\ trees}{number\ of\ sample\ trees} x\ number\ of\ trees\ in\ area$$

5. Add up the fruit in each area.
6. Compare the estimate to the historic production records for the property.

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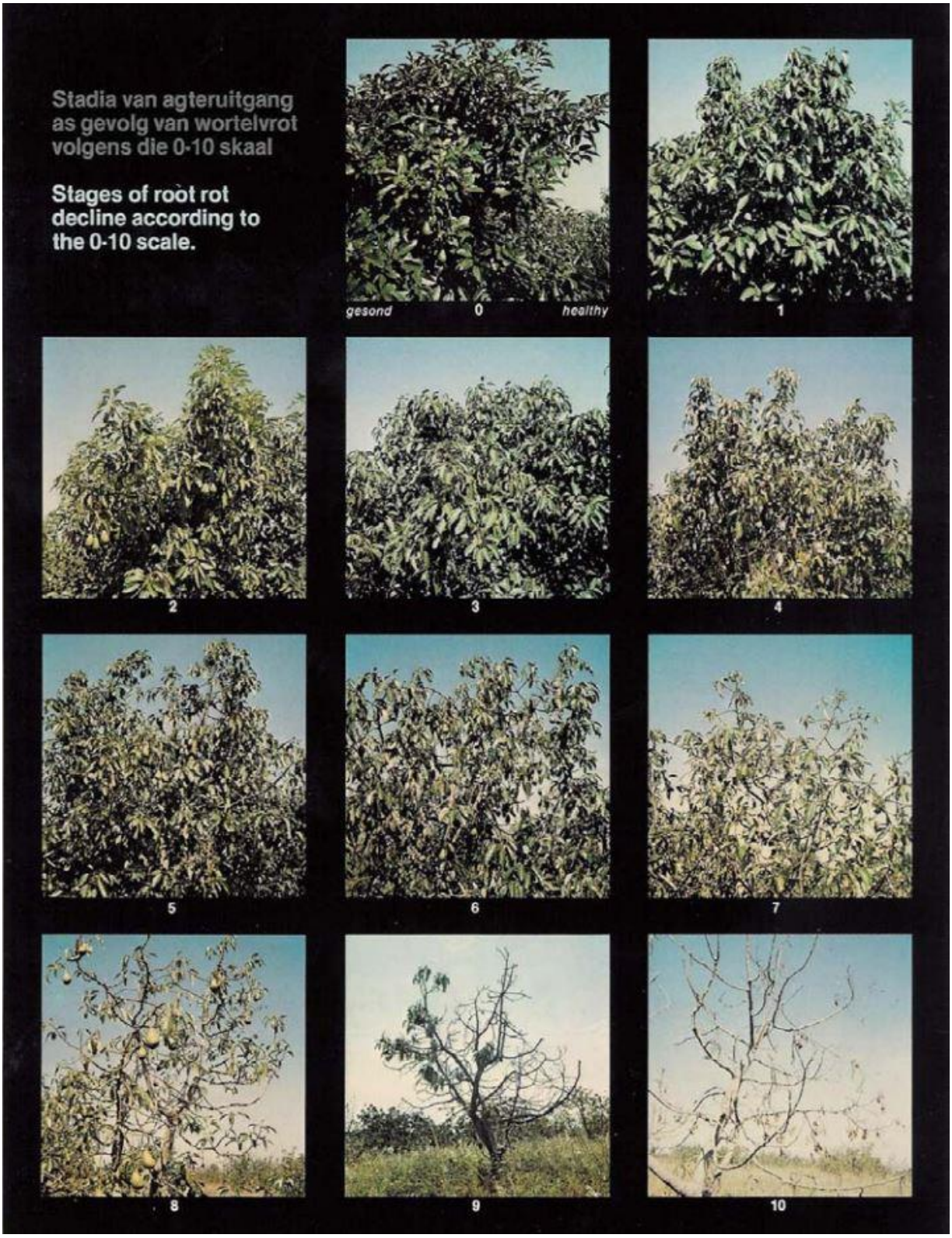
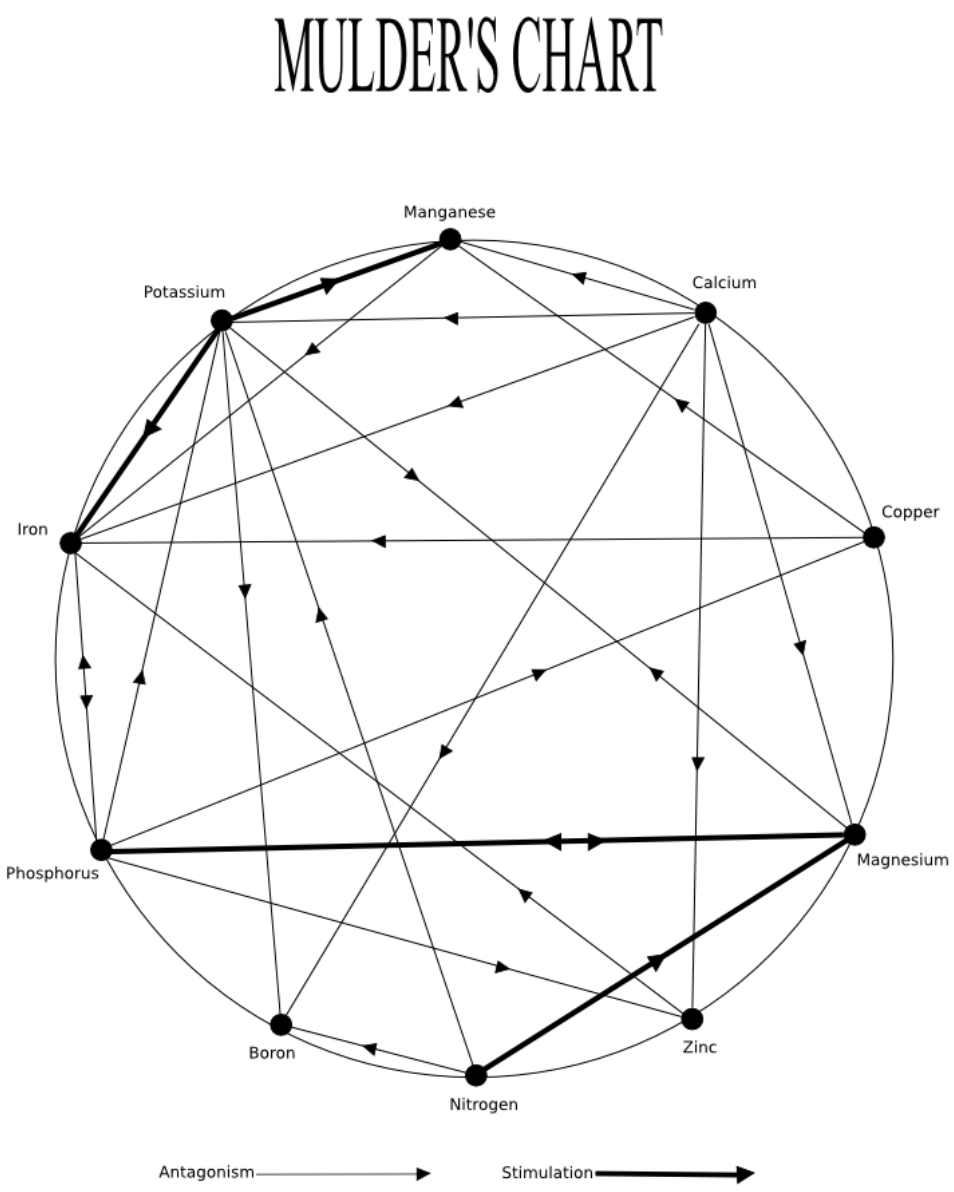
Appendices

APPENDIX 1: CIBA-GEIGY SCALE



APPENDIX 2: MULDERS CHART OF SOIL NUTRIENT INTERACTIONS



APPENDIX 3: NZ AVOCADO ROLL TEST FOR LENTICEL DAMAGE

Roll test for lenticel damage

Method:

1. Clip fruit as per export standard (stalks cut to 5mm or less).
2. Select five good quality clean fruit of mixed sizes ensuring there is enough room in the bucket to get a good 'roll'.
3. Place fruit in a smooth sided 10L bucket.
4. Roll fruit for 15-20 seconds in a clockwise motion.
5. Assess peel damage after 10, 20 and 30 minutes.
6. Calculate sensitivity index and record results.
7. Note weather conditions found on the orchard prior testing (e.g. wind, temperature, overcast)

Interpretation of results:

Sensitivity index = average severity/time in minutes.

Severity = percentage coverage of lenticel damage of each individual fruit.

Average severity = average of lenticel damage across all fruit.

Fail	Pass
Sensitivity index of greater than or equal to 0.5	Sensitivity index of less than 0.5 (e.g.) After 10 mins if average severity <5% After 20 mins if average severity <10% After 30 mins if average severity <15%

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Roll test for lenticel damage

Example:

	10 mins (%)	20 mins (%)	30 mins (%)
Fruit 1	30		
2	35		
3	25		
4	30		
5	30		
Average = (Total %/5)	150/5 = 30		
Severity index = average severity/time in minutes	30/10 = 3		

Notes: Windy and 12°C

					Severity Index			
Date	**Orchard Name/PPIN**	**Location**	**Rain in last 24hrs (mls)**	**Accumulated rainfall last 48hrs +**	**10 mins**	**20 mins**	**30 mins**	**Pass/Fail**
21/09/17	12345	Te Puke	10	25	3			F

*We would like to acknowledge Lynnaire Avers and Ben Tuck from Seeka Ltd for their contribution in developing this protocol.

