Avocado information kit

Reprint – information current in 2001

REPRINT INFORMATION – PLEASE READ!

For updated information please call 13 25 23 or visit the website www.dpi.qld.gov.au

This publication has been reprinted as a digital book without any changes to the content published in 2001. We advise readers to take particular note of the areas most likely to be out-of-date and so requiring further research:

- Chemical recommendations—check with an agronomist or Infopest www.infopest.qld.gov.au
- Financial information—costs and returns listed in this publication are out of date. Please contact an adviser or industry body to assist with identifying more current figures.
- Varieties—new varieties are likely to be available and some older varieties may no longer be recommended. Check with an agronomist, call the Business Information Centre on 13 25 23, visit our website www.dpi.qld.gov.au or contact the industry body.
- Contacts—many of the contact details may have changed and there could be several new contacts available. The industry organisation may be able to assist you to find the information or services you require.
- Organisation names—most government agencies referred to in this publication have had name changes. Contact the Business Information Centre on 13 25 23 or the industry organisation to find out the current name and contact details for these agencies.
- Additional information—many other sources of information are now available for each crop. Contact an agronomist, Business Information Centre on 13 25 23 or the industry organisation for other suggested reading.

Even with these limitations we believe this information kit provides important and valuable information for intending and existing growers.

This publication was last revised in 2001. The information is not current and the accuracy of the information cannot be guaranteed by the State of Queensland.

This information has been made available to assist users to identify issues involved in the production of avocadoes. This information is not to be used or relied upon by users for any purpose which may expose the user or any other person to loss or damage. Users should conduct their own inquiries and rely on their own independent professional advice.

While every care has been taken in preparing this publication, the State of Queensland accepts no responsibility for decisions or actions taken as a result of any data, information, statement or advice, expressed or implied, contained in this publication.

Queensland Government

Growing THE CROP

This section is our recipe for growing and marketing a commercial crop of avocados. To keep the section as brief as possible and easy to follow, we give little explanation with the recommendations. Where more information may help, we refer you to other sections of the kit. Symbols on the left of the page will help you make these links.

Common terms used

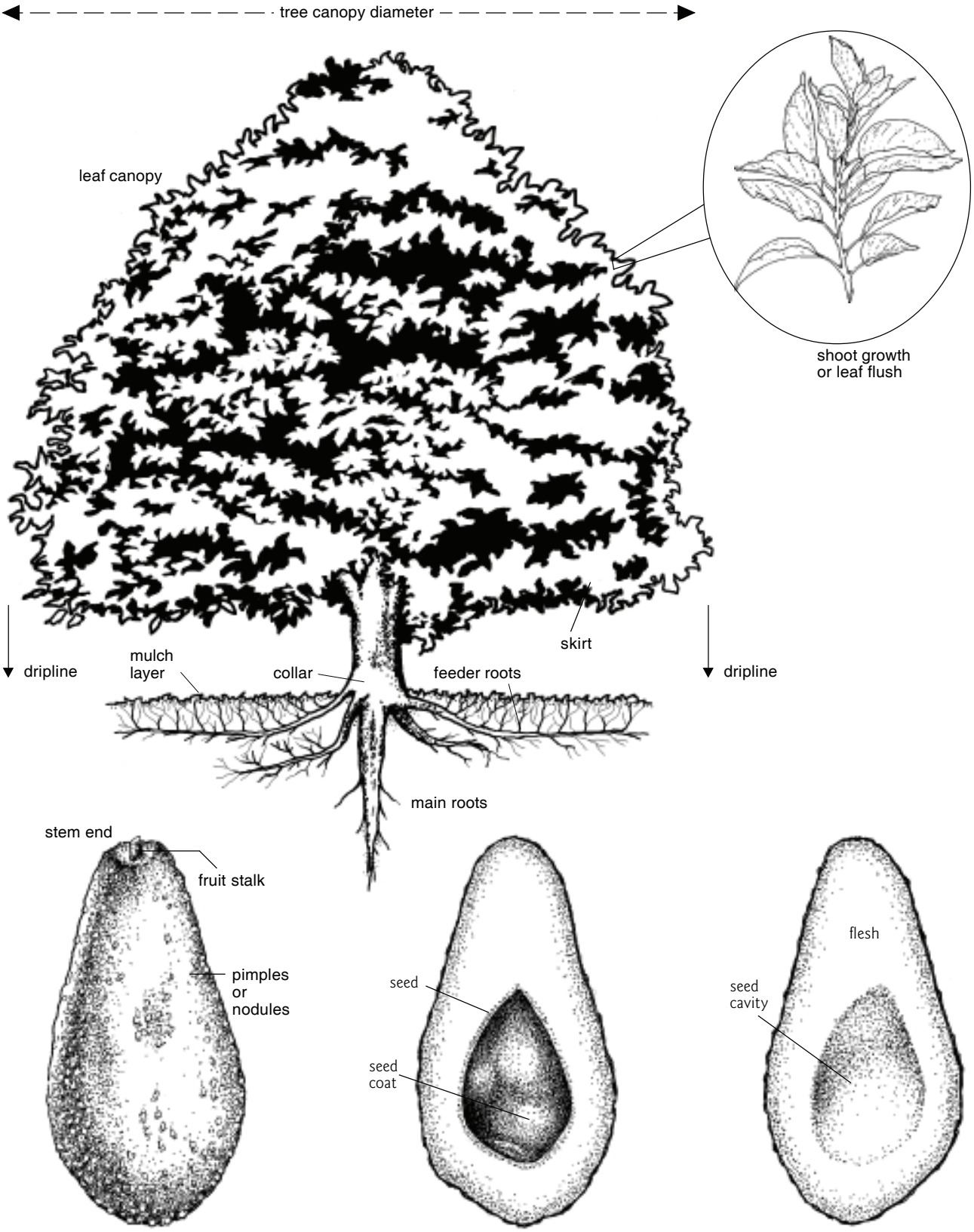


***Figure 1**. Common terms used in this section*

Getting the orchard started

Setting up an avocado orchard that will be profitable in the long term requires careful planning. Mistakes made at this stage are difficult and costly to correct. There are 16 important steps.

Carefully select the site

a key issue

Selecting the right site
Section 4 page 5

As the avocado is highly susceptible to both waterlogging and Phytophthora root rot disease, selection of well-drained sites needs to be given top priority. The recommended minimum depth of well-drained soil required is shown in Table 1.

WARNING
Soil drainage is not only determined by slope. The drainage of water through the soil profile is just as important.

Table 1. *Minimum depth of well-drained soil for avocados*

Average annual rainfall (mm)	Minimum depth of well-drained soil (m)
Less than 700	1.0
700 – 1500	1.5
More than 1500	2.0

Ensure there are no clay layers or rock shelves within the prescribed depth. Where the depth of well-drained soil is marginally less than the minimum depth, mounds and subsurface drains may be required. Avoid hollows where water accumulates, even for short periods. Detailed information on site selection, including instructions on how to properly assess soil drainage, is in Section 4, *Key Issues*.

Plan the orchard layout

Planning the orchard is a complex procedure and we recommend that you get some expert assistance. This is available in some areas from State Government land conservation officers. Here is a brief overview of what's involved in planning an orchard layout.

On a map of the intended orchard site, mark existing features such as roadways, standing timber, gullies and slope direction. Then develop a plan showing access roads, buildings, windbreaks, tree rows, surface drains to control runoff and dam sites. Your aim is to achieve maximum productivity with minimal environmental impact. Figure 2 is an example of an orchard design plan. In developing the orchard plan, there are several important points to consider.

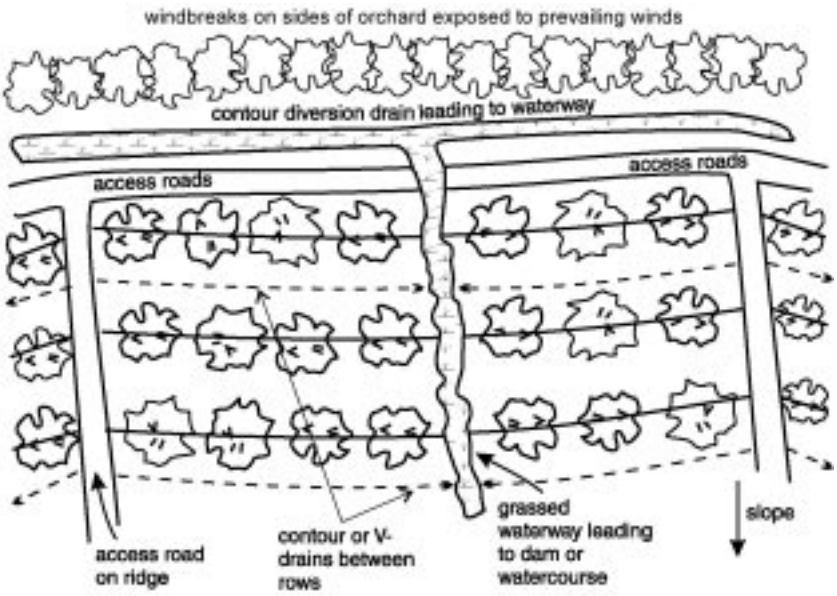


Figure 2. *An example of an orchard design plan*

- **Land clearing**. If you are intending to clear land for your orchard, first check with both your local authority and State Government. In some states, such as Western Australia, clearing of land is strictly controlled and fines can be imposed for improper clearing.
- **Provision for windbreaks**. Windbreaks are vital as wind damages fruit and reduces its quality as well as breaking limbs. Windbreak protection on the sides of the orchard exposed to the main prevailing winds is essential. Use existing stands of timber where possible, otherwise plant windbreaks well before the orchard is established. Expert advice on windbreak design and appropriate species to plant is available in some areas from State Government forestry officers.
- **Slopes.** Flat ground or slopes of less than 15% are preferred as these are less susceptible to soil erosion, allow flexibility with row layout, and enable tractors and machinery to be operated safely. Slopes of more than 15% should be avoided, but if used require specialised design advice.
- **Row direction and length.** Try to run rows in a north-south direction where possible, to maximise light interception for the trees. However, row direction needs to suit the design requirements of the irrigation and drainage systems. Consult a qualified irrigation designer for assistance. Irrigation design advice is generally provided free by irrigation equipment suppliers as part of an agreement to buy irrigation equipment. On slopes of less than 15%, rows can run across or up and down the slope. On slopes of more than 15%, rows must run up and down the slope to allow safe machinery operation. Try to get long rows as these are preferred for efficient mechanisation, but breaks in the rows are needed to facilitate harvesting.
- **Internal soil drainage.** Map the soil drainage by digging a series of test holes across the site to the depth prescribed in Table 1. Record the soil texture, water infiltration and the presence of impervious layers. Avoid

a key issue

Developing a soil drainage map
Section 4 page 7

planting areas with major drainage problems. Earmark marginal drainage problem areas for mounding and/or subsurface drainage.

- **Surface drainage.** Uncontrolled water runoff removes valuable topsoil and exposes roots to desiccation. It may also cause ponding within the orchard, exacerbating waterlogging and root rot problems. Surface drains are essential to carry water safely through the orchard. A drainage system normally consists of a diversion drain at the top of the orchard, cross-slope drains or v-drains within the orchard, and down-slope waterways to carry the water to a dam or watercourse. On slopes of 4 to 15% where rows and drains run across the slope, the ideal is to locate them as close as possible to the contour with a fall of 2 to 5% to remove water safely. Where rows run up and down the slope, major cross-slope contour drains will be required at least every 30 to 50 m down the slope.
- **Mounds.** Where the depth of well-drained topsoil is marginally less than the prescribed depth in Table 1, or where the orchard is in a high rainfall area, low profile mounds may be built to improve soil depth and drainage. Where mounds run across the slope, it is essential to ensure they do not act as dams. There should be a fall of 2 to 5% along the mounds to prevent water ponding within the orchard.
- **Watercourses and dams.** Gullies, creeks and depressions should be disturbed as little as possible. Leave a buffer of trees along gullies and creek banks to keep them stable. Do not plant trees where runoff naturally concentrates in gullies or depressions. Seek professional advice on dam siting and construction from State Government water officers. In Western Australia, discuss the location and size of dams with the Water and Rivers Commission and the local authority to ensure that all regulations are observed.
- **Roadways.** It is important to have all-weather access to the orchard for spraying, harvesting and other operations. Locate access roads on ridgelines wherever possible.

Choose varieties and tree spacing

Varieties

a key issue

Selecting varieties
Section 4 page 44

There are a large number of avocado varieties available for planting, but only two—Hass and Shepard—are currently considered to have good all-round market performance for commercial producers. Sharwil is considered the next best, but requires niche marketing for maximum performance. Selection depends on:

- suitability for your district (based on productivity and fruit quality) —see Table 2;
- where a number of varieties are suitable, whether you are aiming for early, mid or late season production, or a combination. Shepard is an early season variety, Sharwil mid-season and Hass late season.

We suggest that other varieties should only be grown to supply identified niche markets. Don't rely solely on these suggestions. Seek opinion from experienced extension officers, growers, consultants and marketers.

A full analysis of the eight most commonly planted varieties, including the three mentioned here, is in Section 4, *Key Issues*.

NOTE

Table 2 provides a general overview of the suitability of varieties for the various districts. However, within some districts there will be small microclimates that allow exceptions to the rule. Always seek other opinions before deciding.

***Table 2**. District suitability of varieties suggested for planting*

District	Shepard	Sharwil	Hass
Atherton Tableland – north of Walkamin	✔	✔	✗
Atherton Tableland – south of Walkamin	✗	✔	✔
Bundaberg–Childers	✔	✔	✔
Blackall Range, Blackbutt, Tamborine, Toowoomba	✗	✗	✔
South-east Queensland (coastal)	✗	✗	✔
Northern New South Wales (coastal)	✗	✗	✔
Lismore, Coffs Harbour	✗	✗	✔
Sunraysia–Riverland	✗	✗	✔
Perth	✗	✔	✔
Pemberton	✗	✗	✔

Rootstocks

a key issue

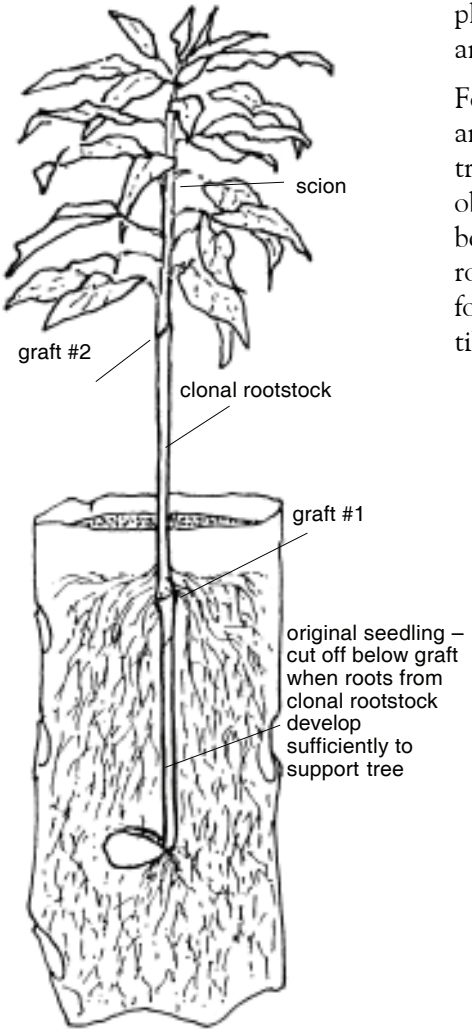
Rootstocks
Section 4 page 55

Trees are bought as varieties grafted onto rootstocks. The choice of a productive rootstock and the use of a uniform rootstock throughout a block are just as important as choosing the right variety.

Some nurseries offer a choice of seedling or clonal rootstocks (Figure 3). Trees propagated on seedling rootstocks are cheaper, but are less uniform. Clonal rootstocks provide uniform growth and vigour and generally produce smaller trees, making them best suited to high-density plantings. Most new plantings in other major producing countries such as South Africa and USA are now based on clonal rootstocks.

For the subtropical regions of eastern Australia, Velvick, Plowman, Nabal and Reed are suggested rootstocks for both seedling and clonally propagated trees. If these rootstocks are unavailable, ask for a Guatemalan rootstock and obtain names of growers using the line available to check its performance before placing an order. For the cooler areas of Western Australia, suggested rootstocks to try are Duke 7, Zutano and Reed. Duke 7 is not recommended for Hass planted in wetter coastal areas because it may increase the susceptibility of the scion variety to anthracnose disease. In Sunraysia and the Riverland, where salinity and high soil pH are important issues, West Indian rootstocks may be more suitable. In these areas, seek local advice before proceeding.

Use only one rootstock for each block of trees.



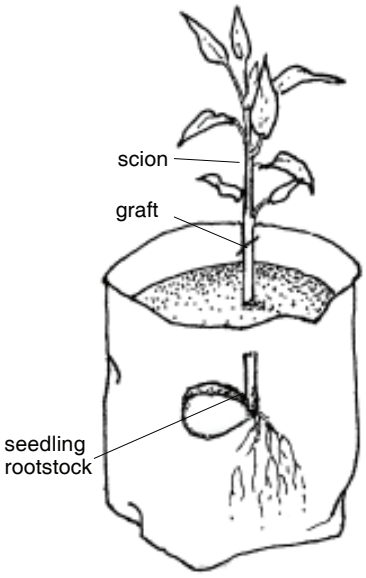


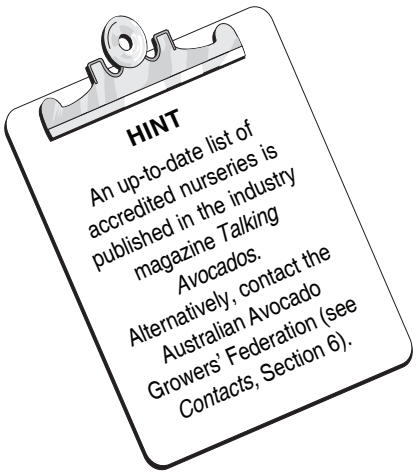
***Figure 3**. Comparison of clonal (left) and seedling rootstocks*

Row and tree spacing

There are three suggested orchard spacing systems (Table 3). The choice of spacing depends on the canopy management system to be used and on the vigour of the variety. For example, Wurtz is a smaller, less vigorous tree and can be planted closer than other varieties.

Table 3. *Row and tree spacing options*

Option	Row spacing (m)	Tree spacing (m)	Number of trees per hectare	Comments
High density	6 – 8	4 – 6	208 – 417	Provides higher early returns per unit area. Tree width and height must be controlled when crowding occurs. Alternatively, remove or transplant trees. Costs more to set up. Not suitable for Fuerte and Sharwil.
Medium density	8 – 9	5 – 7	159 – 250	Tree width and height must be controlled when crowding occurs. Suitable for all varieties.
Low density	10 – 12	10 – 12	69 – 100	Provides lower early returns per unit area but saves costs of tree removal in later years. Results in larger trees, which increases picking costs, reduces picker safety, and lowers fruit production and quality due to the greater difficulty in effectively spraying trees. Not recommended except where land is plentiful and/or cheap.



Note: An alternative to the 'rectangular' spacings above is to plant trees on the square at a spacing of 6 m x 6 m or 7 m x 7 m. This requires tree thinning when crowding occurs.

Arrangement of varieties in orchard

In Australia's main growing of Queensland and New South Wales, varieties do not need to be mixed within a block. Plant only one variety per block, so that it is easier to manage the particular requirements of each variety. However, in colder areas such as Sunraysia–Riverland and the south-west of Western Australia, some mixing of varieties to provide cross-pollination may be beneficial for improving pollination. Seek specialist advice before planting.

Order trees

Once you have chosen your varieties and rootstocks, and worked out your row and tree spacing, calculate the number of trees you need. Order your trees at least 12 months before intended planting from a specialist avocado nursery accredited under the Avocado Nursery Voluntary Accreditation Scheme (ANVAS). These nurseries follow strict hygiene procedures to ensure planting material is of high quality and free from Phytophthora root rot and other diseases such as sunblotch viroid.

Nursery production of trees is a specialist job and we do not recommend that you try to propagate your own trees.

If you plan to export fruit to New Zealand, trees must be indexed and registered as free from sunblotch viroid disease. These trees must be specially ordered from an accredited nursery. Each tree will be supplied with a label containing a unique registration number. Registered trees must be planted at least 15 m from non-registered trees to prevent roots growing together and transferring the viroid. An orchard plan showing the position of each tree must be submitted to the scheme registrar at the Australian Avocado Growers' Federation, and the orchard inspected within three months of planting by an inspector appointed by the registrar. To maintain the registration status of the trees, the following precautions are necessary:

Australian Avocado Growers' Federation
Section 6 page 3

- Either a separate set of cutting tools must be maintained for use only on registered trees, or all cutting tools must be treated with sodium hypochlorite solution before use on registered trees.
- No non-registered avocado trees can be planted within the 15 m separation zone.
- The block of trees must be well maintained at all times.
- The registrar must be advised of any changes—such as topworking, replacement trees or additional trees—to the block of registered trees.

Start to prepare the land

In sites requiring clearing, start at least 12 months before planting. Identify and mark strategically placed existing stands of timber to act as perimeter windbreaks. Before clearing, seek professional advice from State Government forestry officers. Also check with your local authority and State Government for any tree clearing ordinances that may exist. Then clear and stickrake the land where necessary. Failure to effectively stickrake could result in later tree losses to wood rot fungus. Stack the timber into windrows for burning. Don't push it into gullies and depressions. Leave gaps in the windrows every 30 m to allow safe removal of runoff water.

In previously cultivated sites where clearing is unnecessary, start rehabilitating the soil at least 12 months before planting. This involves deep ripping and improving the nutrient and organic matter levels of the soil, as outlined in the following steps.

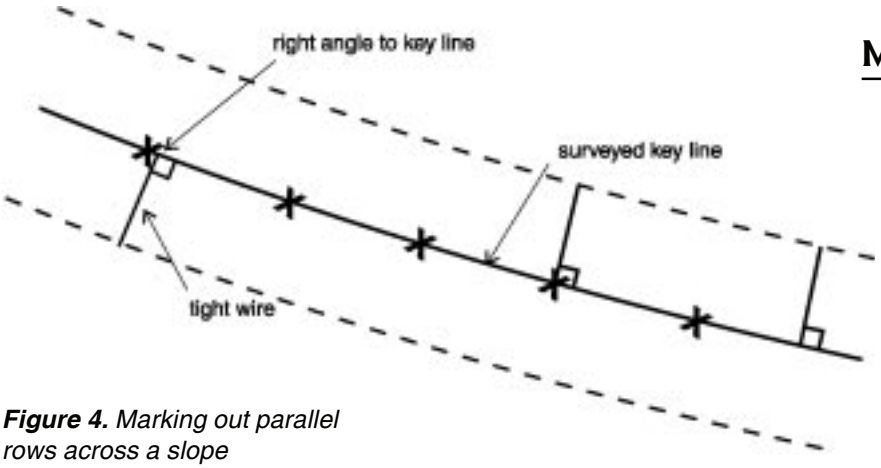


Figure 4. *Marking out parallel rows across a slope*

Mark out the rows

Rows across the slope are marked parallel to a surveyed key line. Wire or rope is tightly stretched between two people at right angles to the key line and points marked every 20 m along the row (Figure 4).

Rows up and down the slope are usually marked at right angles to the contour or parallel to the longest row.

Deep rip along the rows

Deep rip to a depth of at least 60 cm along each row. This is essential if the land has been previously cultivated or grazed. Ripping will also help with the drainage of wet areas. If ripping downhill, lift the toolbar every 30 to 40 m to avoid subsequent water scouring down the rip lines.

Build drains and, where necessary, mounds

Main diversion drain above orchard

On sloping land, construct a major contour diversion drain above the orchard to divert water into a stable waterway or dam. The drain should have

a gradient of 1 to 5% and be large enough to handle water from the catchment above. Keep the steeper sections of the drain furthest from the waterway or dam, unless you have very stable clay soils. Establish a creeping grass, such as carpet grass, couch, African star grass or kikuyu, in the drain channel to prevent scouring.

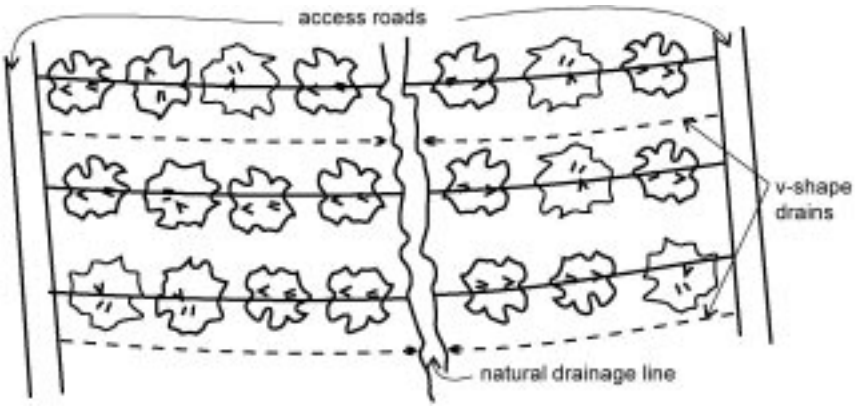


Figure 5. *Across slope rows (plan view)*

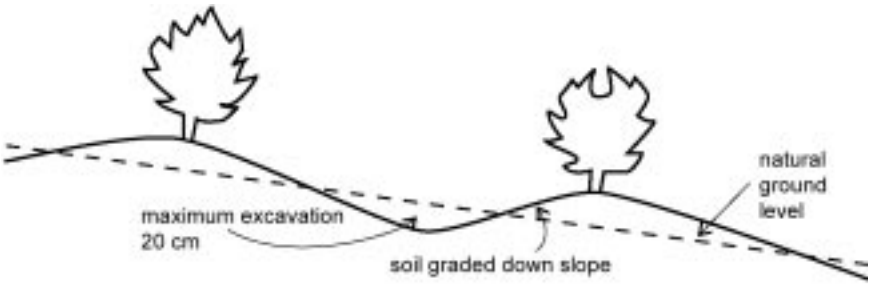


Figure 6. *Across slope rows (cross-section view)*

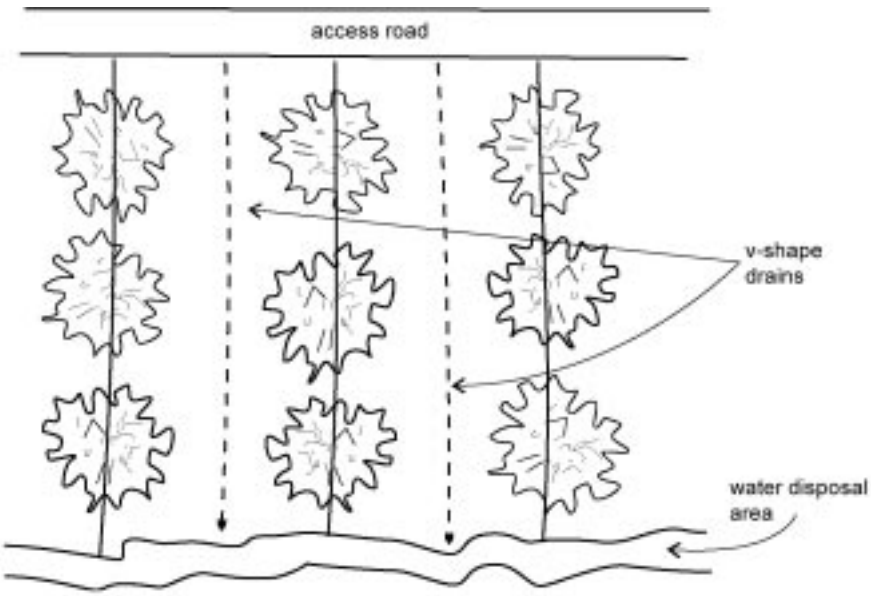


Figure 7. *Down slope rows (plan view)*

Contour drains and/or v-drains within the orchard

Where the depth of well-drained soil is adequate (see Table 1, page 3), there are two options to control water flow and provide drainage within the orchard.

- Either build major contour drains at least every 30 to 50 m or so down the slope. These are built to similar specifications to the main diversion drain.
- Or build shallow, wide v-drains in the centre of the interrow. V-drains have a maximum excavation of 20 cm and are usually built by a grader or tractor-mounted blade.

For rows across the slope, v-drains are constructed every second or third row (Figure 5). Soil from the drain is moved downhill onto the proposed tree row lines (Figure 6).

For rows up and down the slope, v-drains are constructed in every interrow to control side slope runoff and to prevent water scouring down the tree rows (Figure 7). Soil from the drain is moved both ways onto the proposed tree lines (Figure 8).

Immediately after building drains, grass all disturbed areas to minimise erosion. Carpet grass, couch and kikuyu are commonly used. A taller growing grass such as Rhodes grass can also be grown to provide a valuable source of grass mulch for under the trees. Avoid using green panic grass. Its shade tolerance means it may later become a weed problem under the trees.

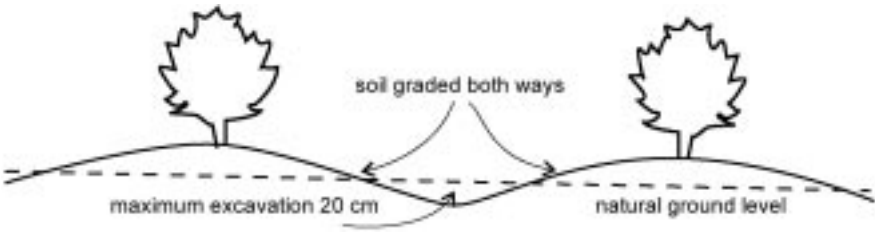


Figure 8. *Down slope rows (cross-section view)*

Mounds

Where the depth of well-drained soil is marginally less than that prescribed in Table 1, or where the orchard is in a high rainfall area, build mounds to increase the soil depth along the rows. Soil is graded from the interrow space to build the mounds. The mounds are essentially an exaggerated version of the v-drain construction, where more soil is excavated from the interrow space and placed on the tree row lines (Figure 9). Do not incorporate the clay subsoil into the mound.

Where the slope is less than 5% and the surface topography is even, build the mounds across the slope with a gradient of 2 to 5%. The gradient is necessary to prevent water ponding within the orchard. Where the slope is greater than 5% and/or the surface topography is uneven, build the mounds up and down the slope. Establish carpet grass, couch, African star grass or kikuyu in the interrow space to minimise soil erosion.

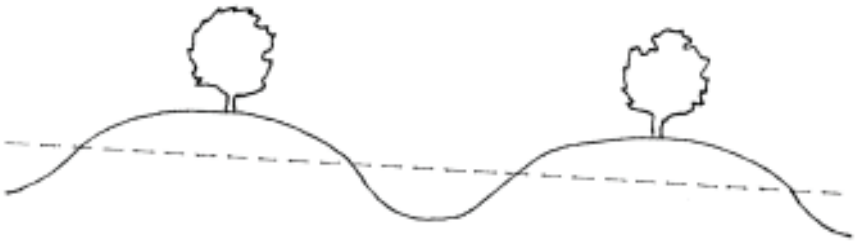


Figure 9. *Mounds (cross-section view)*

Subsurface drainage

Subsurface drains are recommended only where small areas within otherwise well-drained blocks require additional drainage works. They must not be used to compensate for poorly drained soils that should not be used for avocados. Subsurface drains may be tile drains, crushed rock drains or ag-drain pipes. These generally run down the rows with fish bone side arms running out into the tree root zones depending on the amount of drainage required.

Plant windbreak trees

Where windbreak trees are needed to supplement natural timber, plant trees at least 10 to 15 m from the avocado tree rows to allow space for machinery access and to reduce competition for water, nutrients and light.

When planting windbreak trees, deep rip rows to a depth of at least 60 cm before planting. If ripping downhill, lift the toolbar every 30 m to prevent water scouring down the rip lines. Plant the trees 2 to 3 m apart and interplant with a shorter bushy species. Mulch well with coarse straw. Install a separate irrigation line to keep the trees well watered. Regular applications of small quantities of a mixed tree fertiliser will promote rapid growth. Maintain a weed-free area around the trees.

Do a soil analysis and apply required fertilisers

Get a soil analysis done at least six months before planting. This allows plenty of time for required fertilisers to be applied and the soil to be conditioned ready for planting.

Buy a soil sampling kit from your local farm supply store. Follow the sampling instructions and send the sample away for analysis. Results should be back in about two weeks and will be interpreted by the laboratory analysing your sample.

Soil nutrient levels that are considered optimum vary from laboratory to laboratory depending on their extraction procedures. A broad guide to the optimum soil nutrient levels, based on the extraction procedures listed, is shown in Table 4.

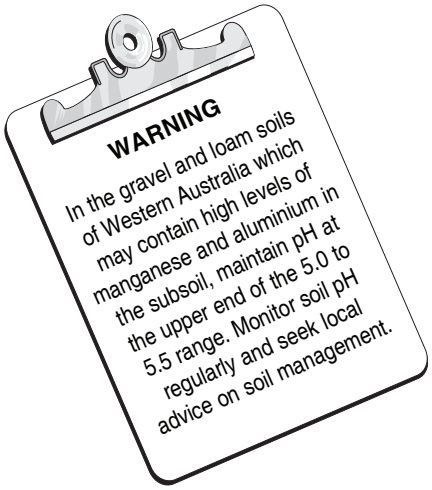
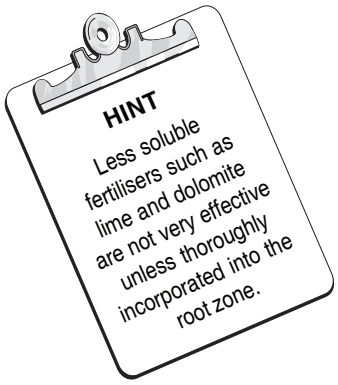


Table 4. *Optimum soil nutrient levels for avocados*

Element (extraction procedure shown in brackets)	Optimum soil levels
pH (1:5 water)	5.0 – 5.5 (6.5 if soil manganese levels are 40 ppm or higher)
pH (1:5 $CaCl_2$)	4.2 – 4.7 (5.6 if soil manganese levels are 40 ppm or higher)
Organic carbon (Walkley-Black)	preferably more than 2.0% C
Sulphate sulphur (Phos. extr.)	more than 20 mg/kg
Nitrate nitrogen (1:5 aqueous extract)	not relevant in pre-planting preparation except to grow a green manure crop
Phosphorus (Colwell or bicarb)	30 – 60 mg/kg P
Potassium (exchangeable)	0.75 – 1.0 meq/100 g K
Calcium (exchangeable)	5.0 – 15.0 meq/100 g Ca
Magnesium (exchangeable)	1.6 – 3.0 meq/100 g Mg
Sodium (exchangeable)	less than 5 meq/100 g Na
Chloride (1:5 aqueous extract)	less than 200 mg/kg Cl
Conductivity (1:5 aqueous extract)	less than 0.15 dS/m
Copper (DTPA)	0.3 – 10.0 mg/kg Cu
Zinc (DTPA)	5 – 10 mg/kg Zn
Manganese (DTPA)	more than 6 mg/kg and less than 40 mg/kg Mn
Iron (DTPA)	4 – 20 mg/kg Fe
Boron (hot calcium chloride)	3 – 12 mg/kg B (clay soils) 2 – 8 mg/kg B (clay loam soils) 0.75 – 3 mg/kg B (loam soils) 0.25 – 1 mg/kg B (sandy loam and sandy soils)
Calcium:magnesium ratio	3 – 5:1
Total cation exchange capacity	preferably more than 7 (the lower the figure, the shorter the recommended interval between fertiliser applications)
Cation balance (%)	calcium 65 – 80; magnesium 10 – 15; potassium 1 – 5; sodium less than 5

Discuss your results with your local fertiliser agent and work out what fertilisers are required. Apply these fertilisers over the orchard site.



Some important issues are:

- As boron leaches very easily, apply the required amounts only a week or two before planting the trees.
- If lime, dolomite, gypsum, superphosphate, copper and zinc are required, apply these now, as the subsequent ripping, cultivation and green manuring will help to thoroughly incorporate them into the intended root zone.
- If the analysis shows gypsum is an option, use it in preference to other forms of calcium. Gypsum is more soluble, supplies calcium without raising the soil pH, and helps to inhibit the development of the Phytophthora root rot fungus.

Cultivate strips along the tree rows

Cultivate one-metre wide strips along the tree rows. As well as incorporating the fertiliser, cultivation along the tree rows helps with tree establishment and reduces initial weed competition. Tined implements or a Turborota are preferred for cultivation. Do not overuse a rotary hoe as it can lead to soil compaction and soil structural problems, as well as causing soil settling of the tree row below ground level. This settling may cause subsequent soil erosion from water movement along the row. Minimise cultivation of other areas of the block to reduce soil erosion.

Grow a green manure crop in the strips

Grow a green manure crop in the cultivated strips and in the interrow as well, where it has not been already grassed. Use hybrid forage sorghum for spring or summer plantings, and oats in autumn or winter. A dressing of urea or nitram two weeks after crop emergence will promote good growth. Slash when the green manure crop is 1.5 m high and disc into the soil. Alternatively, use a 'side throw' slasher/mower to direct the mown crop onto the future tree rows.

Where the interrow does not have to be maintained in a grassed condition to prevent erosion, green manure crops can be grown continuously after the trees are planted until it becomes impractical to continue. See 'Establishing Young Trees', this section page 16.

Mark out the tree planting sites

Mark out each tree planting site with a peg. If a green manure crop was not grown, apply to each planting site either 10 L of poultry manure, or 2 L of pelleted poultry manure, or 20 L of filterpress (mill mud), or 40 L of an organic manure such as cow manure. Spread over a two-square-metre area at each site **at least three months** before planting and immediately incorporate into the soil. Spread coarse mulch such as sorghum stubble 15 cm deep over each site. **Do not place fresh manure or organic materials into the planting holes at or near planting, as it may burn the roots of the young tree.**

The use of fresh (uncomposted) animal manures is restricted in some areas of Western Australia. Consult your local authority or Agriculture Western Australia before use.

a key issue

Irrigation management
Section 4 page 98

Install the irrigation system

Install an irrigation system using a plan prepared for the site by a qualified irrigation designer. The recommended system consists of under-tree minisprinklers (Figure 10) with a micro-spray or micro-jet feature. The micro-spray or micro-jet is used for the first two years to limit water throw. Use sprinklers with an output of between 80 and 160 L/hour. Use one sprinkler per tree. From about the fifth year or earlier, where trees are planted on wide spacings, use two sprinklers per tree. Models that minimise ant colonisation are preferred. In the design of the irrigation system, remember to allow capacity for the extra sprinklers to water your wind-break trees.

Good filtration is important for the successful operation of micro-sprays and minisprinklers.

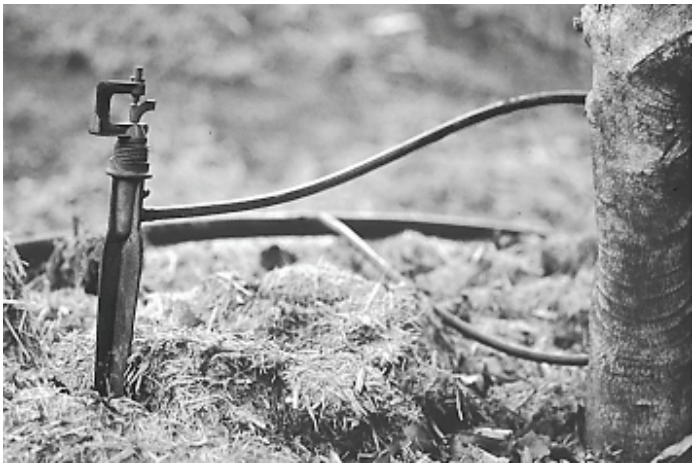


***Figure 10**. A minisprinkler system recommended for avocados*

Plant the trees

When you receive your trees, make sure they have good leaf colour, a sound graft union, are free from pests and diseases, and have been hardened to full sunlight. Don't accept trees that are stunted, root bound or yellow.

When to plant

Container-grown trees can be planted at any time of the year, providing frost is not a problem, adequate water is available and tree guards are used. Autumn is the ideal time to plant. Where frosts occur, plant in September–October. However, trees planted at this time require more watering and general care.

If trees have to be stored while awaiting more favourable planting conditions, it is very important to prevent root rot infection, particularly for ANVAS-accredited trees. Hold trees in a well-protected area and preferably off the ground away from soil. Weldmesh benches on concrete blocks or bricks are ideal. Alternatively store on a raised bed of coarse gravel laid on the ground. Do not store trees on impervious flat surfaces such as plastic sheeting or concrete where water can pool around the base of pots and infection can spread from pot to pot. Also, do not store under older avocado trees or near domestic gardens, both of which are good sources of root rot infection.

Maintain a careful watering program as trees can easily bake in the summer sun and die. Use tank or town water, not dam water as it can carry spores of the root rot fungus. Trees that have been stored under shadecloth should be hardened up before planting by gradually moving them into stronger light over a two-week period.

One to two weeks before planting, spray the trees with phosphonate fungicide to help protect the roots after planting.

Planting procedure

One to two days before planting, water thoroughly to wet tree sites to a depth of 30 cm. Do not plant trees during the hottest part of the day. Follow these planting steps.

1. Dig a hole slightly deeper and wider than the bag. It is best not to use posthole diggers or augers unless the sides of the hole are broken up to reduce any 'polishing' effects. Do not place fertilisers or organic materials into the hole as these may burn the roots of the young tree. It is also unwise to dig deep holes and fill them with topsoil. This can cause the tree to sink as the soil settles.
2. Cut the polythene bag from the plant. Examine the root ball and straighten or trim large roots sticking out at the bottom. Carefully shake away a little of the potting mix from the edge of the root ball to allow better contact with the surrounding soil after planting**. Treat the roots very gently.**
3. Place the tree in the hole, positioning it so that the top of the potting mix is slightly higher than ground level. This allows for later soil subsidence and ensures that the final tree will be at or above ground level rather than below it. Half-fill the hole with soil, gently pressing the soil into contact with the root ball. Care is needed at this stage as the avocado tree has a sensitive root system that is easily damaged. Fill the hole with water. This helps to bring the soil into close contact with the root ball. Allow the water to drain before completing soil filling.
4. Firm soil down gently with your hands (do not use your feet), and build up the level of the soil to just above the top of the potting mix, leaving a slight basin around the tree to hold water (Figure 11). Water again.
5. Where trees are being planted into soils where Phytophthora root rot is known to exist (for example, old avocado tree sites), apply the recommended dose of metalaxyl granules around each tree.
6. Mulch trees with coarse mulch such as cereal or legume stubble, or composted pine bark, to a depth of 10 to 15 cm. Keep the mulch 10 cm away from the trunk to avoid collar rot.
7. Where perimeter windbreaks are poorly developed, use tree guards 1.5 m high (Figure 12). These guards also give some protection from frost, sunburn and damage from hares and wallabies. Use old fertiliser bags or a cheap shadecloth around wooden stakes. Four stakes should be placed in a one-metre square around the tree. Alternatively, three stakes can be used to form a triangular guard. In this case, point the triangle into the direction of the main prevailing wind (Figure 13).

   Where good wind protection is available, trees can be protected from hares and wallabies by loosely wrapping the trunks with either polythene tree protector sleeves or one thickness of sisalation (Figure 14). This also reduces the risk of frost damage and sunburn to the trunk and protects it from herbicide spray drift.

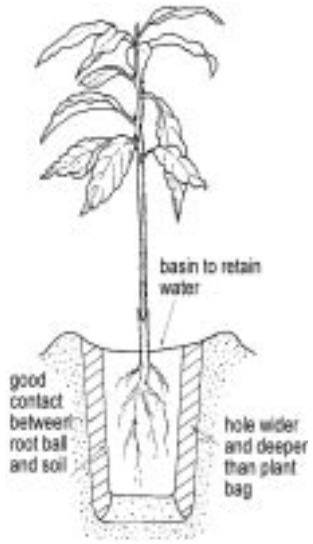


Figure 11. *A correctly planted tree*

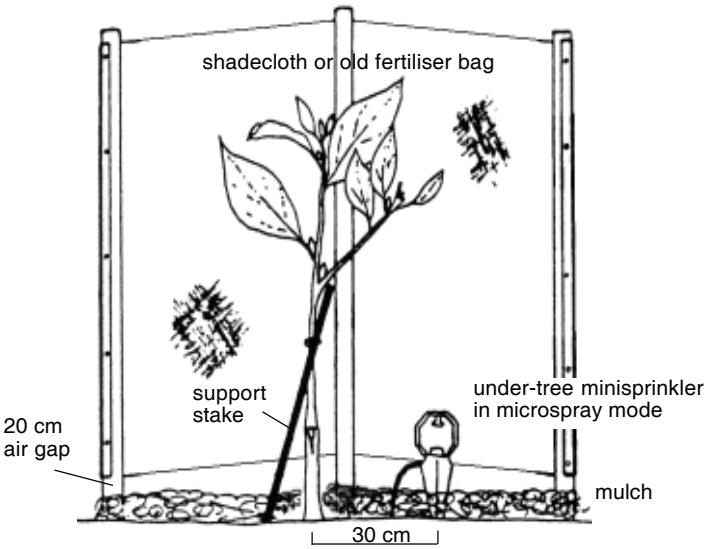


Figure 12. *Tree guards*

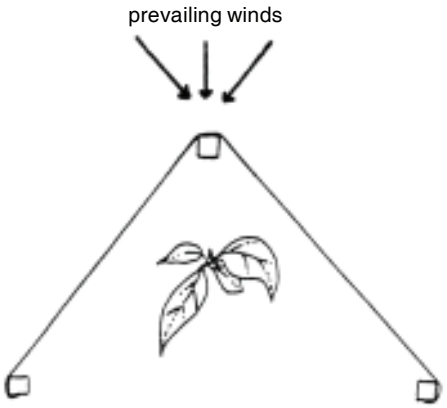


Figure 13. *Plan view of three-stake tree guards showing the positioning of the guards in relation to prevailing wind*

Figure 14. *A polythene tree protector sleeve to protect the tree from animal and herbicide damage*

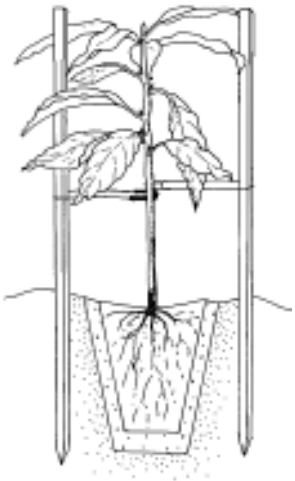


Figure 15. *Staking for newly planted trees*

8. It is also a good idea to stake the trees to prevent collar damage (Figure 15). Drive wooden stakes into the ground outside the root ball of the tree. Place loops of strong rubber or nylon loosely around the trunk and the stakes. Maintain the staking for at least the first 12 months.
9. Where trees are planted in mid-summer, coat the northern and western sides of the trunk and upper parts of limbs with white water-based paint or a solution of talc and bentonite in water (5:1 by weight of talc to bentonite). Both the paint and the bentonite/talc mixture can also be applied as a spray.
10. For the first four weeks, water the trees daily in warm weather and every two to three days in cooler weather. This is particularly important in light sandy soils such as those in Western Australia. Remember that the tree has only a very small root ball and the porous potting mix may dry out very quickly.

Establishing young trees

The first three months are vital in getting young trees established. Follow these recommendations.

Watering

Keep the soil around trees moist at all times. Use under-tree minisprinklers in the micro-spray mode to limit spread of water. Apply 20 to 30 L/tree/week divided between two or three waterings. Note that this is a guide only, and in lighter soils and hotter regions larger amounts and more frequent watering may be necessary. However, be very careful not to overwater, as this will encourage the development of root rot disease.

Fertilising

Do not apply any fertilisers until trees start to grow, then follow the recommendations under 'Managing Young Trees' on page 18 of this section.

Weed control

Keep a one-metre diameter area around trees free from weeds by mulching and hand weeding. Herbicides are not recommended at this stage because of the danger of spray drift onto trunks and leaves.

Root rot prevention

If metalaxyl granules were applied at planting, follow up with a second application about 8 to 12 weeks after planting.

Frost protection

Where frosts occur, damage can be minimised by:

- Wrapping stems with sisalation or tree protector sleeves (Figure 14). Do not wrap the protector too tightly.
- Applying the last fertiliser by the end of March to allow the summer growth to harden off before frosts occur.
- Mounting sprinklers on stakes above trees to apply water during frost periods. Start watering when temperatures fall to 1°C and continue until temperatures rise above 1°C and the ice on plants has melted. Where frosts are mild, under-tree minisprinklers can be used to minimise frost

WARNING

Using irrigation for frost mitigation is only recommended in sites with excellent drainage. As evaporation is low in winter, soils can easily become waterlogged from continuous irrigation.

damage by slightly raising the ground level temperature. These sprinklers are generally set up to start automatically by thermostat at about 2 to 3°C and turn off when the temperature rises a degree or two. The system is generally set up to cycle continuously from station to station with about five to ten minutes for each station.

- Monthly sprays of copper fungicide applied for anthracnose control tend to harden leaves and slow ice formation. Overhead sprinklers, however, will wash off copper sprays.
- Although somewhat impractical, pulling the mulch away from trees during winter will allow the soil to warm during the day and increase air temperatures at night.

Tree shaping

- **Tip pruning (all varieties).** For the first 18 months after planting, regularly pinch out the growing tips to give more side shoots (Figure 16). This helps develop a bushier, more rounded tree, which comes into bearing a little earlier.
- **Central leader pruning (Reed and Lamb Hass only).** Reed and Lamb Hass are more upright growing trees and lend themselves to a central leader training system. This helps develop a 'Christmas tree' shape, which suits the mechanically-pruned, A-shaped hedgerows being adopted for better light interception.

  Central leader tree shaping is often started in the nursery and is recommended to continue for 12 months after planting. It involves the removal of any side branches with a diameter greater than one-half that of the central leader, and cutting back to half length any side branches with a diameter greater than one-third that of the central leader. Side branches with a diameter less than one-third of the central leader are left untouched (Figure 17).

a key issue

Tree training
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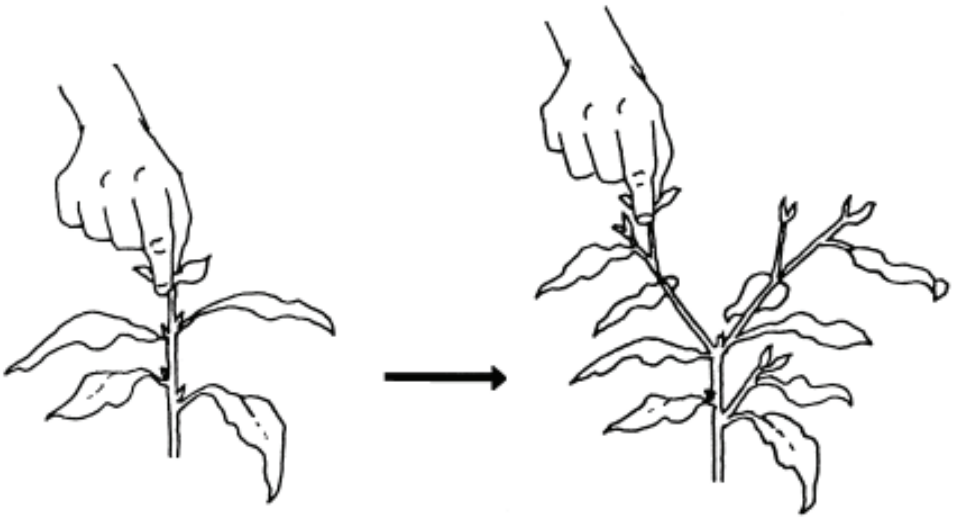


Figure 16. *Tip pruning to encourage side branching*

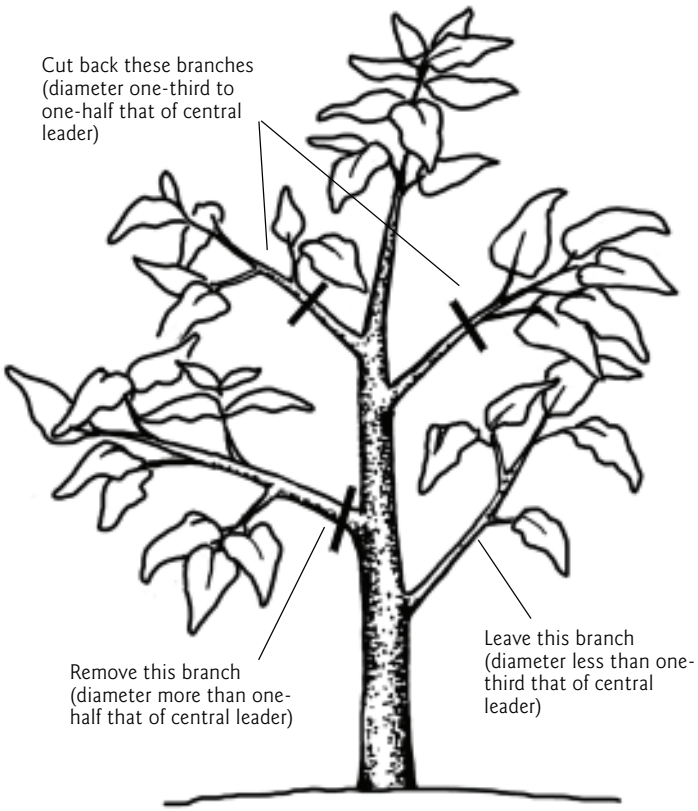


***Figure 17**. Shaping young trees to a central leader*

Green manure cropping

Where the interrow does not have to be maintained in a grassed condition to prevent erosion, green manure crops can be grown continuously after the trees are planted and until it becomes impractical to continue. There are several advantages in doing this:

- It improves the condition of the soil in the interrow space for when the growing avocado roots reach it.
- It provides a valuable source of high quality mulch for use under the trees.
- In windy areas, a well-grown forage sorghum green manure crop can be an effective temporary windbreak for young trees. In this case, strategic bands of forage sorghum can be left to maximise wind protection. For example, you might consider slashing every second row to start with, gradually removing more as machinery access demands it.

Remember that as the trees grow, cultivation for the green manure crop needs to be avoided within a one-metre area outside the dripline. The area available for green manure cropping will be progressively reduced until it becomes too small to be practical.

Managing young trees

During the first couple of years, the aim is to grow a strong, healthy, correctly-shaped canopy of leaves that will produce well in future years. There are six important operations.

Fertilising

If the soil preparation recommendations have been followed, no fertiliser will generally be needed for the first few months until trees start to put on new growth. For autumn-planted trees, start to fertilise in spring, once temperatures begin to rise. Apply small amounts at regular intervals as indicated in Table 5.

Table 5. *Fertiliser guide for trees in the first two years (note the assumptions below the table). All rates shown are in g/tree*

Year	Autumn	Start of spring	Late spring	Mid-summer	Late summer
1	Plant trees	40 g 13:2:13 mixed fertiliser* plus 10 g Solubor plus 25 g zinc sulphate heptahydrate	20 g urea	60 g 13:2:13 mixed fertiliser*	20 g urea plus 10 g Solubor
2	200 g superphosphate plus 75 g 13:2:13 mixed fertiliser*	75 g 13:2:13 mixed fertiliser* plus 10 g Solubor plus 25 g zinc sulphate heptahydrate	20 g urea	100 g 13:2:13 mixed fertiliser*	20 g urea plus 10 g Solubor

* Chloride-free (wherever possible, avoid using fertilisers containing chloride salts)

Assumptions:

1. Trees are planted in autumn.
2. Soil and leaf analysis results are not available. Rates would require modification if analysis results were available.
3. Rates also require modification for tree size, soil type, amount of leaching, variety and whether or not organic fertilisers are used in combination.

Where possible, apply the fertiliser more frequently in smaller amounts than indicated in Table 5. This is particularly relevant on sandier soils, where leaching is more likely. Fertigation is the best method of applying smaller amounts of fertiliser regularly.

Spread the fertiliser around the tree and extending 50 cm beyond the canopy. Keep the fertiliser 10 cm away from the trunk. Irrigate well after each application.

Be careful not to exceed recommended rates and spread all fertilisers, particularly Solubor, very evenly. If in doubt, mix the Solubor in water and spray it on the ground under the trees.

Organic fertilisers

In addition to the above, organic fertilisers are beneficial for the growth of young trees. Apply organic fertilisers in late winter on top of the mulch layer. Suitable amounts are 10 L of poultry manure, or 2 L of pelleted poultry manure or 20 L of filterpress (mill mud)per tree. Keep the material at least 10 cm away from the trunk to avoid collar rot.

The use of fresh (uncomposted) animal manures is restricted in some areas of Western Australia. Consult your local authority or Agriculture Western Australia before use.

Watering

For the first three months while the trees are establishing, keep the soil around trees moist at all times. Use under-tree minisprinklers in the micro-spray mode to limit spread of water. Apply 20 to 30 L/tree/week divided between two or three waterings. Note that this is a guide only and in lighter soils and hotter regions, larger amounts and more frequent watering may be necessary. However, be very careful not to overwater, as this will encourage the development of root rot disease.

From then on, use a soil moisture monitoring system to calculate how often and how much to water. The main choices include:

- tensiometers
- soil moisture sensors
- capacitance probes such as the EnviroSCAN® and Gopher®.

a key issue
Monitoring systems
Section 4 page 104

Table 6 provides a guide to irrigation rates for the first two years for trees grown on the Sunshine Coast of south-east Queensland. The figures are a guide only, as soils vary widely and rainfall is ignored. The only way to compensate accurately for soil type and rainfall is to use a soil moisture monitoring system. Remember that sandy soils hold less water than clayey soils and will require a higher frequency of irrigation with less water being applied per irrigation.

During the first two years, use the minisprinkler in the micro-spray or micro-jet mode to limit the spread of water. Towards the end of the second year, change it back to the minisprinkler mode to increase the diameter of watering and encourage roots to spread.

***Table 6**. Irrigation schedule for young trees (one to two years old), Sunshine Coast, south-east Queensland*

		Spring	Summer	Autumn	Winter
Year 1		50 L/tree/week	60 L/tree/week	30 L/tree/week	20 L/tree/week
Year 2		80 L/tree/week	90 L/tree/week	50 L/tree/week	30 L/tree/week
Number of irrigations/week	Sands	7	7	4	2
	Sandy loams	3	4	3	2
	Clay loams	2	2	2	1

Shaping

Continue the tree shaping operations started at planting—either pinching out of the growing tips (for the first 18 months) or removing and cutting back of side branches to produce a strong central leader (Reed and Lamb Hass only, and only for the first 12 months)—see Figures 16 and 17. Remove lower limbs (skirting) only if these are interfering with irrigation or fertiliser placement. Avoid heavy pruning of any part of the canopy at this stage.

Weed control and mulching

Newly planted trees compete poorly with weeds for water and nutrients. Weed control immediately near the young trees is vital.

Weeds are best controlled by maintaining a grassed or cover-cropped interrow, and mulching and hand weeding around the trees. The mulched area should extend to just beyond the dripline of the trees, making it roughly 2 m wide. If possible, avoid using herbicides at this stage because of the greater risk of damaging or killing young trees.

a key issue

Mulching
Section 4 page 70

Besides reducing weeds, mulching increases soil organic matter, improves soil structure and reduces fluctuations in root temperature. This helps minimise the impact of Phytophthora root rot disease. Mulching also increases water retention and may reduce irrigation frequency and amount.

Apply mulch 10 to 15 cm deep in late spring after the soil has warmed up and trees have started to grow again. Keep it 10 cm away from the trunk to avoid collar rot.

Mulch may be brought in or grown on-site. If brought in, coarse hay or straw such as sorghum or soybean stubble is preferred. The grassed interrow area is a valuable source of on-site mulch. Rather than keeping the grass short, delay slashing until it is 15 to 20 cm high. This ensures there is enough grass available for use as mulch. Too frequent slashing is costly, contributes to compaction and favours the growth of unproductive grasses and weeds. Use side delivery mowers to direct the slashings under the trees. It is also possible to grow oats and lupins in the interrow to use as mulch materials.

Hand-pull weeds that grow through the mulch. Hand weeding for the first year after planting is recommended because of the risk of herbicide damage to the young trees. Where herbicides have to be used, spot spray very carefully and do not allow the herbicide to contact any green part of the tree, including the trunk. To minimise drift, use a shielded, low-pressure fan nozzle or a rope wick applicator. Trunk protection, as shown in Figure 14, also helps protect the tree from accidental spray drift. Use low volumes of herbicide spray to prevent the chemical soaking through the mulch layer and being taken up by the tree roots.

For young trees, use the herbicides listed in Table 7. Herbicides such as glyphosate and glufosinate-ammonium (Basta) are not recommended because they pose too great a risk of damage should herbicide drift onto the trunk and leaves of young trees.

Table 7. *Herbicides for weed control in young trees*

Chemical	Weeds controlled	Products
paraquat	Most grasses and some broadleaf weeds	Boa Gramoxone Maxitop Nuquat Paradox Paraquat Shirquat Sprayquat Spraytop
paraquat + diquat	Most grasses and broadleaf weeds	Sprayseed Tryquat
fluazifop-P	Grasses only	Fusilade
haloxyfop-R	Grasses only	Appeal Asset Gallant West Typhoon Verdict

Do not cultivate within at least 1 m of the tree dripline. Avocados have a shallow root system, which can be easily damaged. Don't use brush cutters because of the risk of damage to the trunk.

Pest and disease management

The main issue in young trees is to protect them against Phytophthora root rot. A suggested chemical protection program is shown in Table 8.

Until fruit are produced, there are no other pest or disease problems that require routine treatment. However, trees should be regularly checked for leaf feeding insect pests such as mites, scale insects, Monolepta beetles (redshouldered leaf beetles), loopers and leafrollers. Growers in north Queensland should also keep an eye on Cercospora leaf spot. Be particularly vigilant in the spring and early summer for swarms of Monolepta beetles, particularly in leafy varieties like Wurtz. Beetles can arrive suddenly in large numbers and can cause significant leaf damage in just a few hours.

Growers planting in old sugarcane land should watch for cane beetles chewing the roots. Growers in south-west Western Australia should watch for garden weevil damage in spring and early summer. Damage can be significant on young trees.

Where pests and diseases warrant treatment, follow the recommendations in the *Pest and Disease Management Handy Guide*.

***Table 8**. Chemical protection program for root rot in young trees (inclusion in the list means that products are registered in at least Queensland; for other states, check the* Problem Solver Handy Guide *which shows current registration details for each state as well as registered trade names)*

Year	Chemical	Rate	Timing	Notes
1	metalaxyl	25 – 50 g of commercial product (healthy trees) to 100 g (sick trees) per square metre of ground under the tree canopy.	Treat up to three times at about 8 to 12 week intervals, but particularly during wet conditions.	Granular treatment applied to the surface of the ground under the tree.
2	phosphonate fungicide	250 – 300 mL/ 100 L of commercial product.	Apply six foliar sprays at 6 week intervals between September and April. Only effective if applied to healthy trees with good leaf cover.	Foliar spray. Do not mix with copper fungicides, particularly copper hydroxide. Do not apply within 10 days of a dimethoate spray. Good coverage of the bark as well as the leaves helps protect against trunk canker.

Additional root rot management practices

In addition to the chemical prevention program, two other practices are recommended to help minimise the impact of root rot disease:

- **Removing fruit from sick trees.** Remove fruit set on young trees affected by root rot as soon as possible. This helps the tree cope with the disease by removing a significant drain on the reduced root system.
- **Orchard quarantine.** To minimise further introduction of the root rot fungus into the orchard, it is a good idea to restrict unnecessary vehicle and people movement into the orchard. Footbaths containing copper fungicide and located at convenient access points are a simple but effective measure. To be effective in the long term, these measures need to be combined with interception drains that prevent soil and water from outside moving into the orchard.

Managing bearing trees

Once trees get close to bearing at the end of the second year, the management focus changes. Before fruiting, the aim is to build a strong healthy framework. In mature trees, the aim is to achieve maximum production of quality fruit, manage vegetative growth and maintain a healthy root system.

High performing trees follow a definite crop cycle of shoot growth, flowering and fruit development. The aim of management is to manipulate fertilising, watering and other operations to maintain the trees in this desired cycle. There are nine important operations.

Root rot management

a key issue

Root rot management
Section 4 page 65

Root rot is the most important disease of avocado and a major emphasis is needed to keep it under control. This involves an integrated program of seven elements (Figure 18).

The elements of Phytophthora-tolerant rootstocks, disease-free nursery trees and careful selection of the site to ensure free drainage have been addressed in the orchard establishment recommendations earlier in this section. Once trees reach bearing age, root rot management then involves judicious chemical use and various cultural measures.

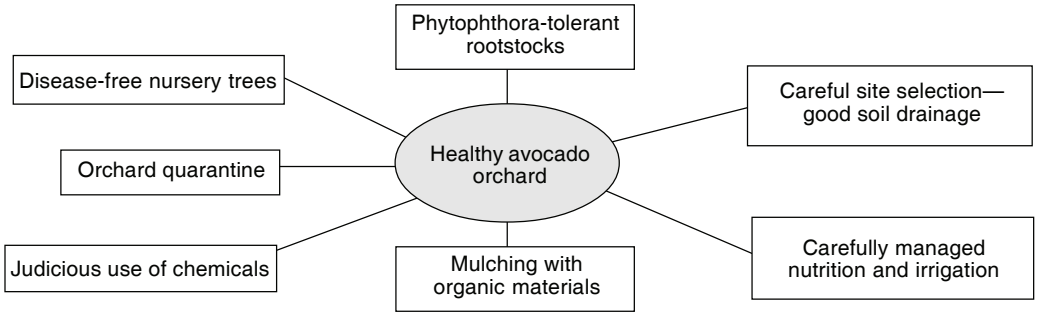


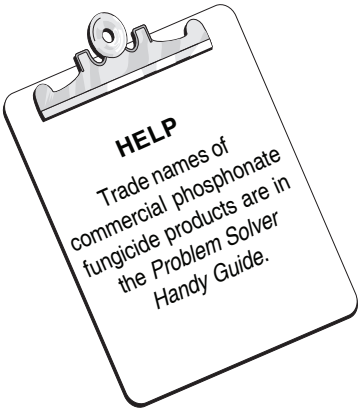
Figure 18. *The seven elements of an integrated program to manage root rot disease*

Chemical control

In most situations we recommend that all trees in the orchard be treated every year with phosphonate fungicide. Do not assume that because trees appear healthy, root rot is absent.

There are two treatment options:

- trunk injection
- foliar spraying.



Trunk injection

Trunk injection is currently the most reliable and effective method for controlling Phytophthora root rot. A minimum trunk diameter of about 4 cm (equivalent to a canopy diameter of about 2 m) is required for practical injection. Use a registered commercial phosphonate fungicide containing 20% active ingredient. Products containing 40% active ingredient should be diluted with an equal quantity of water to break them down to 20% active ingredient. Inject only when the predicted daily maximum temperature is above 23°C. Where possible, use a neutrally buffered product with a pH of about 7.0.

Treatment schedules are based on assessing the current condition of the tree with respect to root rot. Four categories are commonly used (Table 9).

***Table 9**. Categories for assessing root rot*

Healthy	Mildly affected
	
• Full canopy of leaves • Leaves dark green • No significant leaf drop at flowering	• Canopy starting to thin a little • Leaves slightly pale • Leaves wilting in middle of day • Significant leaf drop during flowering

Moderately affected	Severely affected
	
• Only 40 to 60% of the leaves left on the tree—large sections of branches visible through canopy • Much of canopy yellow • Leaves wilted most of the time • Significant leaf drop during flowering	• Less than 40% of the leaves left on the tree—canopy sparse, with most of the branches visible • All leaves yellow • All leaves permanently wilted • Significant leaf drop during flowering

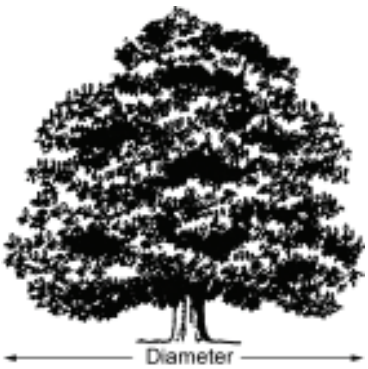
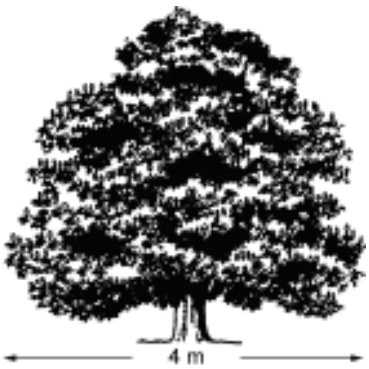
Treatment schedules based on these root rot severity categories are shown in Table 10.

Table 10. *Treatment schedules for trunk injection*

Condition of tree	Treatment schedule
Healthy trees	Inject once a year during early summer, six weeks after the end of the spring leaf flush (about mid-January in south-east Queensland).
Trees with mild to moderate symptoms	Inject twice a year, the first in spring–early summer when the spring flush has matured (late November in south-east Queensland), and the second in about mid-March.
Severely affected trees	Inject twice a year, the first in early spring (September in south-east Queensland) and the second in about mid-March.

To calculate how much chemical to inject, use the formula in Table 11.

Table 11. *Formula for calculating injection quantity*

Formula	Example
(1) Measure tree canopy diameter in metres.	(2) Tree canopy diameter = 4 m.
	

Formula	Example
(2) Multiply tree canopy diameter by 15 to obtain the total amount of 20% phosphonate product in mL to inject.	(2) 4 m x 15 = 60 mL of 20% phosphonate product.
(3) Divide the figure obtained from Step 2 by 20 mL (the maximum volume of chemical per injection site) to give the number of injection points. (Note: Round up if a fraction is obtained, for example round 3.5 up to 4 injection points.)	(3) 60 mL ÷ 20 mL = 3 injection points of 20 mL each.

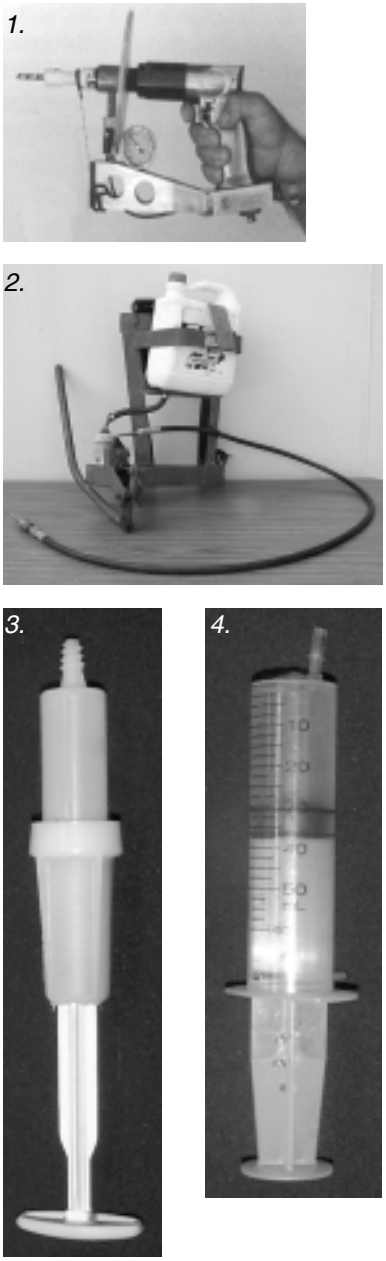


Figure 19. *Some of the equipment available for tree injection*
1. the Sidewinder® injector
2. the Rawlins® hydraulic knapsack
3. Chemjet® tree injector
4. modified veterinary syringe

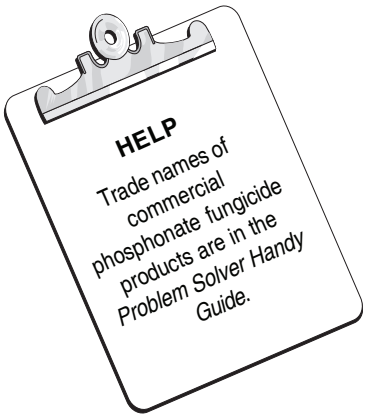
Injection method

- Water trees the night before injecting, particularly where low pressure Chemjet® syringes are being used. Inject the next morning. Start as early as possible and plan to finish by 11 a.m., by which time uptake of the chemical is significantly reduced.
- Inject at points evenly spaced around the main trunk or in the main limbs. Do not inject at the points where branches join the main trunk. Do not inject immediately above or below previous injection holes. Target the sapwood under the bark.
- Using a cordless drill, drill injection holes about 2 cm deep at a downward angle of about 45°. Carefully withdraw drill so as not to enlarge the bore of the hole. Ensure the drill bit is an appropriate size for the injection equipment being used.
- Use either Chemjet® tree injectors, the Sidewinder® injection equipment, the Rawlins® hydraulic knapsack or modified veterinary syringes (Figure 19). Follow the manufacturer's directions carefully. Do not apply excessive pressure as this may damage the bark. With low-pressure injection systems, holes do not have to be plugged with silicone or putty after injection. Where veterinary syringes and Chemjet® tree injectors are used (these are left in place after injection), the chemical should have been absorbed within 15 to 30 minutes of injection. If this has not happened, it generally means that either the applicator has not been properly inserted or the tree has closed down. Leave the injectors in place or try again early in the morning of the following day.
- After treatment, flush all injection equipment with clean water to remove any residues of the chemical. The dry crystals of potassium phosphonate may damage rubber and plastic components.

Foliar sprays

Foliar sprays of phosphonate fungicide are a suitable alternative to trunk injection for trees that have no apparent symptoms of root rot. These trees must have a good canopy of healthy or near healthy leaves to allow sufficient uptake of the chemical. Foliar spraying is also recommended for trees with trunks less than 4 cm in diameter, where trunk injection is not practical.

The technique involves applying several sprays of a registered commercial phosphonate fungicide between spring and autumn. Regular applications are required because only small amounts of the chemical are absorbed from each spray. Six sprays of phosphonate fungicide at a concentration of 0.1% active ingredient are recommended, with no more than six weeks between sprays. To achieve this concentration, 300 mL of a 40% commercial phosphonate product are mixed in 100 L of water. For products with 20 or 30% active ingredients, follow label directions.



Leaf burn and/or significant leaf drop may be a problem if phosphonate fungicide is applied with copper **hydroxide**, if copper **hydroxide** residues are present on leaves or if it is applied 7 to 10 days before or after sprays containing dimethoate. A risk may exist with other chemicals as well, depending on the quality of the water used in the spray mixture. As a result, it is often difficult to find at least six 'safe' spray points during the spring to autumn period. An additional problem is that phosphonate fungicide cannot generally be tank mixed with endosulfan insecticide because of spray incompatibility.

Different formulations of phosphonate fungicide sprays are being studied to reduce the number of sprays and to make it easier to find safe spray points. If these become registered, details will be included in Agrilink updates.

A summary of the chemical control options for established trees is shown in Table 12.

***Table 12**. Options for root rot control in established trees using phosphonate fungicide*

	Healthy trees	Mildly affected	Moderately affected	Severely affected
Injection	✔ 1 injection	✔ 2 injections	✔ 2 injections	✔ 2 injections
OR				
Foliar spraying	✔ 6 sprays	✗	✗	✗

Note: For young trees that are too small to inject, apply metalaxyl granules to the ground under the trees.

To assist with the timing and management of root rot, the AVOMAN decision support software can provide sophisticated customised recommendations for individual orchards.

Cultural measures for root rot management

Integrated root rot management
Section 4 page 66

Cultural measures are as important as chemicals in the management of root rot and need to be given as much emphasis in orchard management. Here is a summary of the main points.

- Ensure there is adequate surface drainage of water within the orchard at all times. If you followed the drainage layout recommendations given earlier in this section, you should not have problems. However, regularly check that drains are working and that water is not ponding. If wet spots are discovered after tree establishment, rectify immediately with surface or underground drains or both.
- Keep a deep layer of mulch or compost under and around trees to 0.5 m beyond the edge of the dripline until trees are able to provide their own natural deep litter mulch from natural leaf fall.

  Preferred mulches are coarse, fibrous materials such as wheat and barley straw, sorghum stubble and composted pinebark. Cane tops are also suitable but may cause a drop in soil pH. Where used, monitor soil pH carefully to ascertain whether extra liming materials are required. Where possible, avoid bagasse or sawdust (they remain too wet after rain and are hard to rewet when dry), and peanut husks (provide too much nitrogen and may introduce Verticillium wilt).

Apply mulch to a depth of 10 to 15 cm in August. Keep mulch about 10 cm away from tree trunks to avoid collar rot. Renew mulch in December if roots are unprotected.

- Maintain soil pH at 5.0 to 5.5 (1:5 water test) unless soil manganese levels exceed 40 mg/kg. Do not use lime or dolomite unless pH falls below 5.0 (1:5 water test). Use regular soil and leaf analysis to ensure phosphorus, calcium and boron levels in the soil are adequate. Where possible, use ammonium and sulphate types of fertiliser rather than nitrate and chloride types.

  Warning: In the gravel and loam soils of Western Australia, which may contain high levels of manganese and aluminium in the subsoil, maintain pH at the upper end of the 5.0 to 5.5 range. Monitor soil pH regularly and seek local advice on soil management.
- Keep soil moist but do not overwater. Use soil moisture monitoring devices such as tensiometers or capacitance probes to carefully schedule irrigation rates and timing.
- If fruit begin to develop on trees moderately or severely affected by root rot, remove fruit as soon as possible to help the tree recover.
- Restrict unnecessary vehicle and people movement into the orchard and provide footbaths at convenient access points.

Pest and disease management (other than root rot)

Besides root rot, there are generally only two other major pest or disease problems that may require routine application of chemicals. These are anthracnose (a fungal disease present in all avocado growing areas) and fruitspotting bug (an insect pest found only in eastern Australia).

For other pests and diseases, spraying is recommended only when populations, as indicated by monitoring, reach levels likely to cause economic damage.

Anthracnose

more info
Anthracnose
Symptoms: Section 5 pages 20, 36, 38
Spray schedule: *Pest and Disease Management Handy Guide*
Management: Section 4 page 129

Anthracnose affects the fruit and is favoured by warm (above 15°C), humid conditions. Although it is worse in the wetter coastal areas and on thin-skinned varieties such as Fuerte, all varieties in all growing areas are susceptible and spraying is recommended in all orchards. Infection may occur at any stage of fruit development, so regular preventative spraying is required throughout most of the period that fruit is on the tree.

In Western Australia with its Mediterranean climate, the critical periods are autumn and spring, but avoid spraying during flowering.

Once fruit harvest is completed, remove any dead branches and old fruit that are still hanging in the tree. This reduces the reservoir of fungal spores.

Fruitspotting bug

Fruitspotting bug is the major pest of fruit in most production areas of eastern Australia. Most orchards in these areas will need some level of spraying, with those close to bushland requiring the most attention. We recommend that the orchard be monitored from fruit set for early spotting bug damage, with spraying to start as soon as damage is detected. Concentrate the monitoring on those trees closest to the bushland, as these are likely to be the ones first affected.

more info
Fruitspotting bug
Damage: Section 5 pages 25, 30, 33, 41
Spray schedule: *Pest and Disease Management Handy Guide*
Management: Section 4 page 113

Once damage has been detected, routine spraying is then recommended through until the end of March at fortnightly to monthly intervals, depending on severity of attack. Continue monitoring the orchard to evaluate the effectiveness of the spray program.

Chemicals used for fruitspotting bug control are generally compatible with the copper sprays used for anthracnose, and can be mixed together. However, always follow the mixing recommendations on the labels of the chemicals you are using.

Other pests

more info
Other pests
Photos: Section 5
Monitoring and spray schedule: *Pest and Disease Management Handy Guide*
Management: Section 4 pages 114–118

Other pests are best controlled by carefully monitoring trees, recording pest levels and applying appropriate insecticides only when levels are likely to cause economic damage (referred to as 'action levels'). Pest levels below the action level are not considered damaging enough to warrant the cost of treatment. Pest levels above the action level mean that steps should be taken immediately to prevent further pest build-up.

You can do the monitoring but we recommend you use professional pest consultants where these are available. If you do your own monitoring, some introductory guidelines plus detailed information on each pest including monitoring, action levels and appropriate treatments is in Section 4, *Key Issues*. However, it is best to get some training from a pest consultant before starting.

Pesticide application and safety

a key issue
Spray application and safety
Section 4 page 130

Aim to get good coverage of fruit and leaves over the whole tree. Air blast sprayers are preferred and recommended. Detailed information on spray application and setting up air blast sprayers is in Section 4, *Key issues*.

A separate, smaller spray unit is required for applying herbicides and a coarse spray hand gun or tractor-mounted splatter sprayer is needed for applying fruit fly bait sprays.

Spray equipment must be well maintained and calibrated regularly to ensure sufficient chemical is applied to each tree. Operators should have a full understanding of the equipment and the principles of spray application to maximise efficiency and minimise spray drift.

Before using any chemical, always read the label and follow its directions. Observe full safety precautions including the use of safety equipment and protective clothing.

It is essential that all growers attend an approved Chemical Users Course. Special accreditation is required to buy and use the pesticide endosulfan, and detailed records of all applications of the chemical must be maintained.

Pesticide compatibilities

It is often convenient to mix pesticides and apply them in the one operation. This saves time and may be done safely with some of the pesticides commonly used. However, knowledge of the compatibility of every pesticide used is incomplete and we recommend that you follow the advice on the labels of the chemicals you are using.

Pesticide compatibility can also be influenced by the pH of the water being used for spray application.

Fertilising

a key issue
Nutrition management
Section 4 page 76

About two years from planting (Queensland and northern New South Wales), the tree is usually ready to carry its first crop. Fertiliser application should then be strictly based on leaf and soil analysis. Monitoring of leaf and soil nutrient levels is very important as it makes sure that you apply the right amount of fertiliser to maintain optimum tree growth and fruit quality. This maximises your profit as well as preventing potential environmental problems with excess fertiliser leaching into streams and groundwater.

It is best to do both leaf and soil analysis each year. A less preferred option is to do leaf analysis every year and soil analysis every second or third year. Leaf and soil analysis kits, with full sampling instructions, are available from your local fertiliser agent.

Leaf analysis

Sample leaves for leaf analysis in autumn when trees have stopped producing new leaves and the summer flush leaves have hardened off. In most areas, this will be around April–May, but may be as late as June in cooler areas. Select the youngest fully expanded leaf from the summer flush (Figure 20); these leaves will be about eight weeks old. Collect four leaves per tree from 10 trees to make a sample of 40 leaves. Leaves from each variety are collected separately, using trees of a similar age. Sample only healthy trees, avoiding sampling the outside rows of blocks or trees at the ends of rows. Mark the trees or record their position for future reference.

Send the sample/s away for analysis. Results should be back in about two weeks and the laboratory analysing your sample will interpret the results. Alternatively, engage a consultant to interpret the results or use the AVOMAN software for a highly customised interpretation. The optimum ranges for leaf nutrient levels are shown in Table 13.

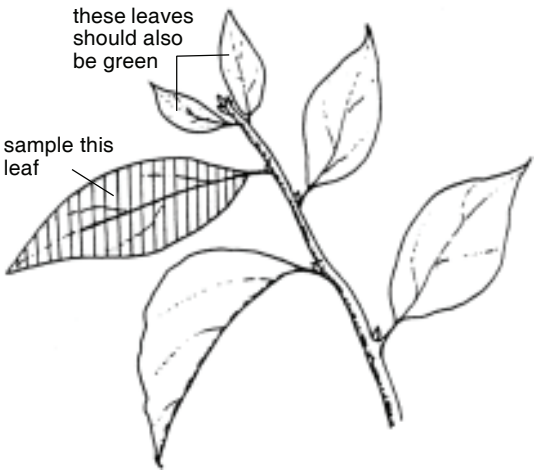
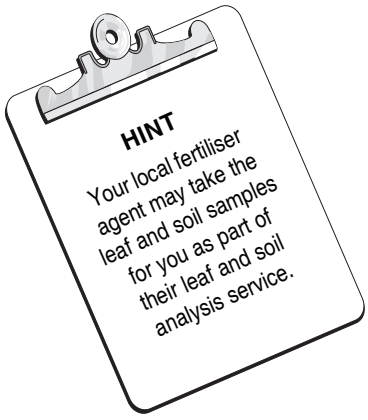


Figure 20. *Leaves to sample for leaf analysis*

Table 13. *Optimum leaf nutrient ranges for avocado*

Nutrient	Optimum range
Nitrogen (% N)	1.6 – 2.0 (Fuerte and Sharwil) 2.2 – 2.6 (all other varieties)
Sulphur (%S)	0.2 – 0.6
Phosphorus (% P)	0.08 – 0.25
Potassium (% K)	0.75 – 2.0
Calcium (% Ca)	1.0 – 3.0
Magnesium (% Mg)	0.25 – 0.8
Zinc (ppm Zn)	40 – 80
Copper (ppm Cu)	5 – 15
Sodium (% Na)	less than 0.25
Chloride (% Cl)	less than 0.25
Iron (ppm Fe)	50 – 200 but not considered reliable
Boron (ppm B)	40 – 60
Manganese (ppm Mn)	30 – 500

WARNING: The leaf nutrient ranges shown here apply to leaves analysed by the dried tissue technique. They do not apply to results obtained from sap analysis techniques.



more info

Optimum ranges for soil nutrient levels. This section Table 4 page 11

Soil analysis

Soil analysis is used primarily to monitor and adjust pH and nutrients such as calcium, magnesium, phosphorus and boron. Take soil samples from under the tree canopy, within the wetted area of the sprinklers, and at least 30 cm from the tree trunk (Figure 21). Follow the instructions carefully, particularly those relating to the recommended number and location of subsamples. This is essential to ensure the sample is representative of the block. Where possible, avoid taking soil samples from locations under the tree where bands of fertiliser have been previously applied.

Send the sample/s away for analysis. Results should be back in about two weeks and the laboratory analysing your sample will interpret the results. Alternatively, engage a consultant to interpret the results or use the AVOMAN software for a highly customised interpretation.

Sample from under the tree canopy, within the wetted area of the sprinkler, and no closer than 30 cm from the tree trunk. Sample at a depth of 0 – 15 cm, and if possible also from 15 – 30 cm.

Figure 21. *Soil sampling*

Fertiliser needs

To work out what fertilisers need to be applied, compare your leaf and soil analysis results with the optimum levels. Note that a poor relationship has been shown between soil and leaf analysis for phosphorus, zinc, boron and iron.

The laboratory analysing your sample, your local farm supply agent or a specialist consultant can help you work out the most appropriate types and rates of fertiliser required. Alternatively, the AVOMAN software can produce a highly customised result.

In a typical well-managed orchard with reasonably fertile soil, nitrogen, potassium and boron are likely to be the only nutrients that need to be added each year. Phosphorus is also likely to be required in phosphorus-fixing soils such as red krasnozems and red earths, and in soils with historically low phosphorus levels, such as those in much of south-west Western Australia. Zinc may require adjustment every two years and calcium and magnesium every two to three years. Other nutrients generally require little or no adjustment for long periods.

Table 14 provides some broad guidelines for fertiliser use based on well managed orchards using leaf and soil analysis. **Note that the figures are a guide only as soils vary widely. The only way to compensate for this is to use leaf and soil analysis on your own farm and have the results interpreted properly by the AVOMAN software or nutrition experts. The guidelines are based on using straight fertilisers, not mixed fertilisers, and the timing applies to orchards in south-east Queensland and northern New South Wales.**

Table 14. *Broad guidelines for fertiliser use*

Nitrogen applied as urea (46% N)

	Either: Broadcast fertiliser program (g/tree)				**Or: Fertigation program** (g/tree/week)
Tree canopy diameter (m)	**After summer fruit drop (about mid-January)**	**Four weeks later (about mid-February)**	**Four weeks later (about mid-March)**	**Four weeks later (about mid-April)**	**Applied weekly over 16 weeks from January to April**
2	32	32	24	12	5
4	120	120	100	50	18
6	280	280	200	100	40
8	500	500	360	180	70
10	750	750	575	300	110
12	1100	1100	800	400	160

Notes on nitrogen use:

1. All rates apply to healthy trees with optimum nitrogen leaf levels and carrying average crop loads. Increase rates if growth is weak, if leaf nitrogen levels are below the optimum or if trees are carrying heavy crops. Decrease if growth is too vigorous, if leaf nitrogen levels are above the optimum or if crop load is light.
2. Fertigation rates are based on 75% of the broadcast fertiliser rates.
3. Do not apply nitrogen outside the January to April period unless trees are sick with root rot and need rehabilitation, or leaf analysis indicates a nitrogen deficiency.
4. For the broadcast program, spread the fertiliser under the canopy and for a metre or so outside it. As trees reach mature age, tree roots extend into the middle of the row so the whole of the orchard should receive some fertiliser. However, set up the fertiliser spreader to place most of the fertiliser under the tree canopy.

Potassium as potassium sulphate (sulphate of potash, 41% K)

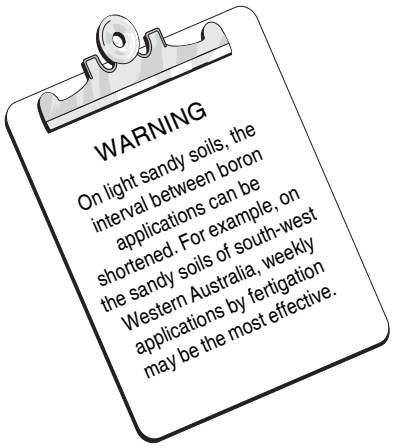
	Either: Broadcast fertiliser program (g/tree)				**Or: Fertigation program** (g/tree/week)
Tree canopy diameter (m)	**After summer fruit drop (about mid-January)**	**Four weeks later (about mid-February)**	**Four weeks later (about mid-March)**	**Four weeks later (about mid-April)**	**Applied weekly over 16 weeks from January to April**
2	25	25	20	10	4
4	100	100	70	30	15
6	220	220	160	80	30
8	400	400	300	150	60
10	600	600	480	220	90
12	880	880	660	330	130

Notes on potassium use:

1. All rates apply to healthy trees with optimum potassium leaf levels. Increase rates if leaf potassium levels are below the optimum. Decrease if leaf potassium levels are above the optimum.
2. Fertigation rates are based on 75% of the broadcast fertiliser rates.
3. For the broadcast program, spread the fertiliser under the canopy and for a metre or so outside it. As trees reach mature age, tree roots extend into the middle of the row so the whole of the orchard should receive some fertiliser. However, set up the fertiliser spreader to place most of the fertiliser under the tree canopy.

Boron

	Either: Applied through weedicide boom to the ground under the tree		Or: applied through the fertigation system	
Tree canopy diameter (m)	Six applications of the rate below: start one month before flower bud break and then every two months. Rates of either borax or Solubor (g/application/tree). **Note that rates listed here are for SANDY soils; adjust rates for other soil types as indicated under notes below.**		The rate below applied once per month over 12 months (g of Solubor/tree/month). **Note that rates listed here are for SANDY soils; adjust rates for other soil types as indicated under notes below.**	
	Either borax	**Or Solubor**	**Either Solubor**	**Or boric acid**
2	3	2	0.75	0.90
4	13	7	2.5	3.0
6	30	15	6	7.0
8	50	30	10	12.0
10	80	40	16	19.0
12	110	60	23	27.0



Notes on boron use:

1. **All rates above apply to a sandy soil. For other soil types, multiply the rates above by the following factors: sandy loam – 1.3; loam – 1.7; clay loam – 2.0.**
2. Fertigation rates are based on 75% of the boom rates.
3. If leaf levels fall below 30 ppm, apply a foliar spray of Solubor at a rate of 1 g/L at the start of flowering.
4. Boron is a trace element and excessive amounts or uneven application can cause boron toxicity. For this reason, calculate and measure amounts very carefully, and apply very evenly to the ground under the tree. Because of the small amounts involved on a per tree basis, it is extremely difficult to apply boron evenly in solid form. We recommend it is applied in solution through a weedicide boom or by fertigation.
5. Do not apply boron by fertigation through irrigation systems that wet only small areas of ground (for example dripper systems), as areas of application may be too concentrated, leading to possible boron toxicity.

Zinc

Applied once in spring in a 30 cm wide band at the dripline (see Figure 22).
Approximate rates of zinc sulphate heptahydrate as g/tree.
(Note: no zinc applications are necessary where leaf levels are above 40 ppm.)

Tree canopy diameter (m)	Leaf Zn level 30 to 40 ppm		Leaf zinc level below 30 ppm	
	Clay loam	**Loam or lighter**	**Clay loam**	**Loam or lighter**
2	18	15	35	30
4	70	60	140	110
6	160	125	310	250
8	280	220	560	450
10	440	350	870	700
12	630	500	1250	1000

Notes on zinc use:

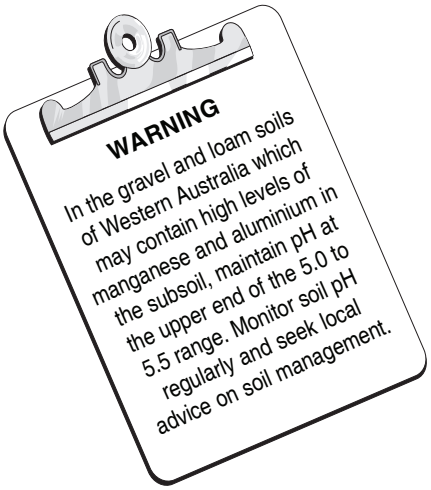
1. Rates are based on the assumptions that no zinc deficiency symptoms are present; soil pH is less than 6.5 (1:5 water); and soil phosphorus is less than 80 ppm (Colwell test).

Figure 22. Banding of zinc at the dripline of an individual tree. An alternative for hedgerows is to run the band in a straight line down the tree row at the dripline

2. Zinc banding is recommended to concentrate the zinc and help root uptake. This is because zinc is relatively insoluble and may be tied up in the soil if applied evenly over the root zone. Also, zinc toxicity is rarely a problem. Note that this is the opposite to boron which is highly soluble and readily taken up, and where toxicity is common and potentially serious.
3. Zinc uptake is best when it is banded on the soil surface; application through the irrigation system is not recommended. However, if fertigation is used, increase the above rates by 50%.
4. Foliar application of zinc is not an alternative to concentrated band application as leaf uptake is ineffective and leaf analysis results will be distorted by zinc residues on the leaf surface.

Other nutrients

Phosphorus	As requirements vary so widely between growing areas, no indicative rates can be safely provided without leaf and soil analysis. Regular applications may be required in phosphorus-fixing soils and in soils with historically low phosphorus levels, such as those in much of south-west Western Australia.
Calcium and magnesium	Application of calcium and magnesium fertiliser needs to be considered in relation to soil pH and the Ca:Mg ratio. This can only be safely done with knowledge of soil analysis results. However, in general, where soil pH is at or above 5.5 (1:5 water), use gypsum to supply calcium and either Epsom salts or Granomag to supply magnesium. Where pH is below 5.5 (1:5 water), use lime or dolomite to adjust pH to 5.5 (1:5 water). The choice of lime or dolomite depends on calcium and magnesium levels in the soil. Do not apply more than 2 t/ha of lime or dolomite in any one application. Use very fine lime such as Hortilime as this is more soluble. Also use a lime that has a high neutralising value, ideally over 95. Adjustment of soil pH and calcium and magnesium levels is normally only required once every two to three years. Apply either in February–March, so that summer rains can help to wash the materials into the soil, or at the start of winter. Apply over the whole orchard area. Do not apply just before or after an application of boron. Where soil manganese levels are 40 mg/kg or above, aim for a pH of 6.5 (1:5 water test) to avoid manganese toxicity. Soil pH has a significant effect on Phytophthora root rot activity. It is important to regularly monitor soil pH so that it can be maintained at the optimum level of 5.0 to 5.5 (1:5 water).
Other trace elements	Adjustment rarely required. Leaf and soil analysis essential to determine need and rates.



Irrigation

a key issue

Irrigation management
Section 4 page 98

Continue using the soil moisture monitoring devices (tensiometers, soil moisture sensors, or capacitance probes) recommended earlier for young trees as a guide to irrigation rates and timing.

In the absence of monitoring systems, Table 15 provides a guide to irrigation rates for bearing trees growing on the Sunshine Coast of south-east Queensland. Remember that the figures are a guide only, as soils vary widely and rainfall is ignored. The only way to compensate accurately for soil type and rainfall is to use a soil moisture monitoring system. Note also that lighter sandy soils such as sandy loams hold less water than heavier soils such as clay loams. These lighter soils require a higher frequency of irrigation with less water being applied per irrigation.

The critical period for watering extends from early spring through until autumn.

Because of the significance of root rot, it is important to prevent sprinklers at the ends of lines weeping after irrigation and over-wetting the root zone. The best way to overcome this is to fit a flushing valve at the end of each line.

***Table 15**. Irrigation schedule for bearing trees (three years and older) on the Sunshine Coast of Queensland; all rates in L/tree/week*

Tree diameter (m)		Spring	Summer	Autumn	Winter
2		200	220	120	70
3		350	400	200	120
4		400	500	250	140
5		650	700	400	220
6		950	1000	550	300
7		1300	1400	750	400
8		1700	1900	1000	600
10		2600	3000	1500	900
No irrigation required if rainfall exceeds:		**30 mm**	**40 mm**	**20 mm**	**12 mm**
Number of irrigations per week (Note: rates above to be divided between these irrigations)	Sand	7	7	4	2
	Sandy loam	3	4	3	2
	Loam	2	3	2	1
	Clay loam	2	2	2	1

Pruning to control tree size and shape

a key issue

Tree spacing and canopy management
Section 4 page 58

Yields and fruit quality decline when trees crowd and shade each other. Operating costs are also higher in large trees. To keep fruit yield, quality and operating costs at a reasonable level, a canopy management plan is required for the orchard.

There are several options depending on the initial orchard spacing and layout. Further details and background reading on canopy management are in Section 4, *Key Issues*. Read this in conjunction with the notes below.

more info

Standard tree spacing
This section pages 6–7

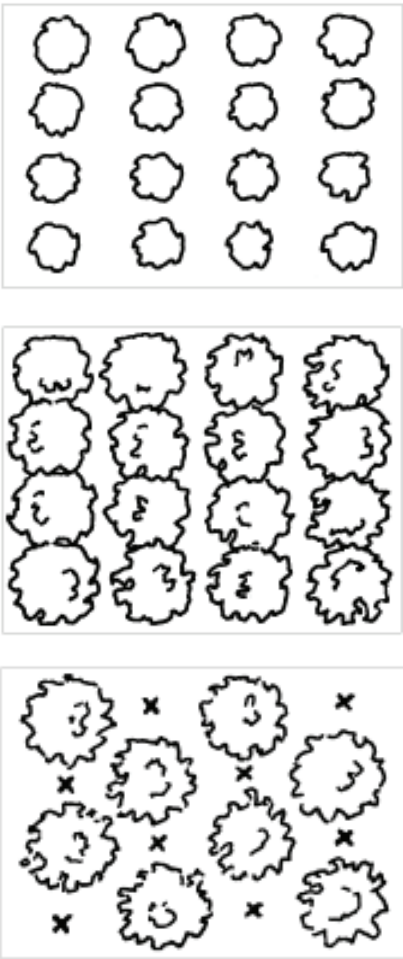


***Figure 23**. Tree thinning in a close-planted orchard on a square grid. Top: orchard layout at planting; Centre: orchard before thinning; Bottom: orchard after thinning (trees removed on diagonal)*

Tree thinning

Depending on initial tree spacing, tree thinning can involve the removal of alternate rows of trees, the removal of alternate trees within the rows, or the removal of trees on the diagonal. The removal of alternate rows would only be contemplated where trees were initially planted with this in mind at row spacings of 7 m or less. Removal of alternate trees within rows would only be necessary where trees were initially close planted at less than the standard tree spacing recommended earlier in this section.

The other tree removal situation is where trees are removed on the diagonal in 6 m x 6 m or 7 m x 7 m square plantings where the row direction can be changed. After tree removal, the spacing becomes 8.5 m x 8.5 m and 9.9 m x 9.9 m respectively. Tree removal on the diagonal presents some difficulties. For example, the irrigation laterals would need to be relocated to the new row and surface drains may need to be re-constructed.

With Hass growing under south-east Queensland conditions, the first tree thinning is required six to seven years after planting. The remaining trees are then pruned using the staghorning, selective limb removal or hedgerowing techniques outlined below. This will need to start around 10 years after planting. The tree thinning process is shown in Figure 23.

Thinning is best done in spring. Avoid thinning in winter as there is a greater risk of Verticillium wilt spreading from the dead roots of thinned trees to roots of the remaining trees.

Staghorning

Staghorning involves cutting trees back to a stump above the graft union (called a staghorn) and allowing them to re-grow (Figure 24). Trees are staghorned when they are too large to be effectively managed.

Staghorn trees at the start of spring as temperatures increase. Avoid staghorning during winter as the trees are more susceptible to Verticillium wilt. Immediately paint the newly exposed limbs with white plastic paint to protect them from sunburn. A coarse spray of a 5:1 talc:bentonite sun protection preparation is an alternative to paint. A common mixture is T63B talc and Truebond MW® bentonite in water. Seek advice on mixing rates and directions before proceeding.

Where possible, only staghorn healthy trees. If trees are affected by root rot, ensure that they are injected with phosphonate fungicide in the March before staghorning. With unhealthy trees, leave one branch on the tree intact as a 'nurse branch' (preferably on the western side of the tree to provide some shade), until there is a significant amount of regrowth (Figure 25).

To maintain uniform light interception, staghorn all trees in a block or section of the orchard rather than alternate rows or alternate trees. To maintain cash flow, sections of the orchard can be staghorned at intervals, so that within the orchard there are sections at various stages of production and regrowth. Remember to reduce fertiliser and water rates in line with the reduced size of the tree canopy. Recycle the prunings back into the orchard as mulch by using chipping or macerating equipment.

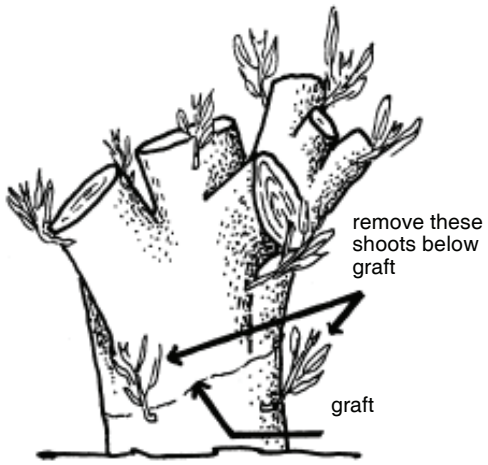


***Figure 24**. A staghorned tree*

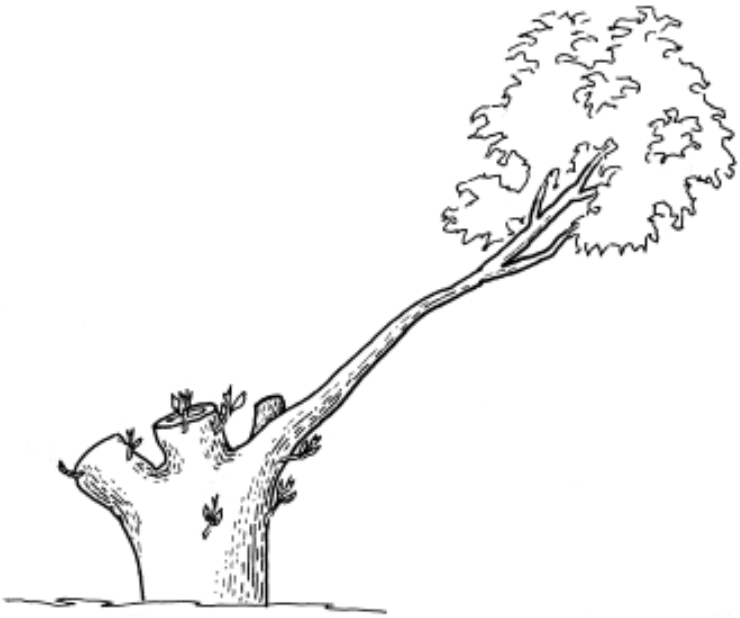


***Figure 25**. Leave one intact 'nurse branch' when staghorning unhealthy trees*

Selective limb removal

Selective limb removal is used to maintain tree size and interrow access in the medium term. Most growers practise it to some degree. Eventually, it will need to be combined with tree thinning, staghorning or hedgerowing.
There are four main types of selective limb removal:

- As trees grow, some limbs protrude out into the laneway, reducing orchard access. These limbs should be removed at a point close to the main trunk.
- Some degree of tree height control can be achieved by selective limb removal. In this instance, limbs are removed back to a major horizontal branch. This helps reduce the vigour of regrowth but works best with heavy cropping varieties where regrowth is naturally less vigorous.
- Low branches, where fruit is likely to contact the ground, should be removed.
- From time to time, removal of a major limb in the centre northern part of the tree will improve light penetration and rejuvenate productivity.

Selective limb removal is also used in hedgerow pruning to open up the canopy at the hedge trimming face (see below).

Hedgerow pruning

Hedgerow pruning involves pruning rows of trees to an A-shape with commercial hedgerowing equipment (Figure 26). **WARNING: This technique is still being evaluated under Australian conditions. Although showing some promise, it is not yet formally recommended. Growers are encouraged to try it on selected blocks of trees only.**

more info
Pruning contractors
Section 6 page 8

Contractors who provide hedgerow pruning services are available in some areas. Where contractors are unavailable, or in small orchards, a similar hedging effect can be achieved by using petrol or hydraulic 'pole' chainsaws. A cherry picker is useful to gain extra height and reach.

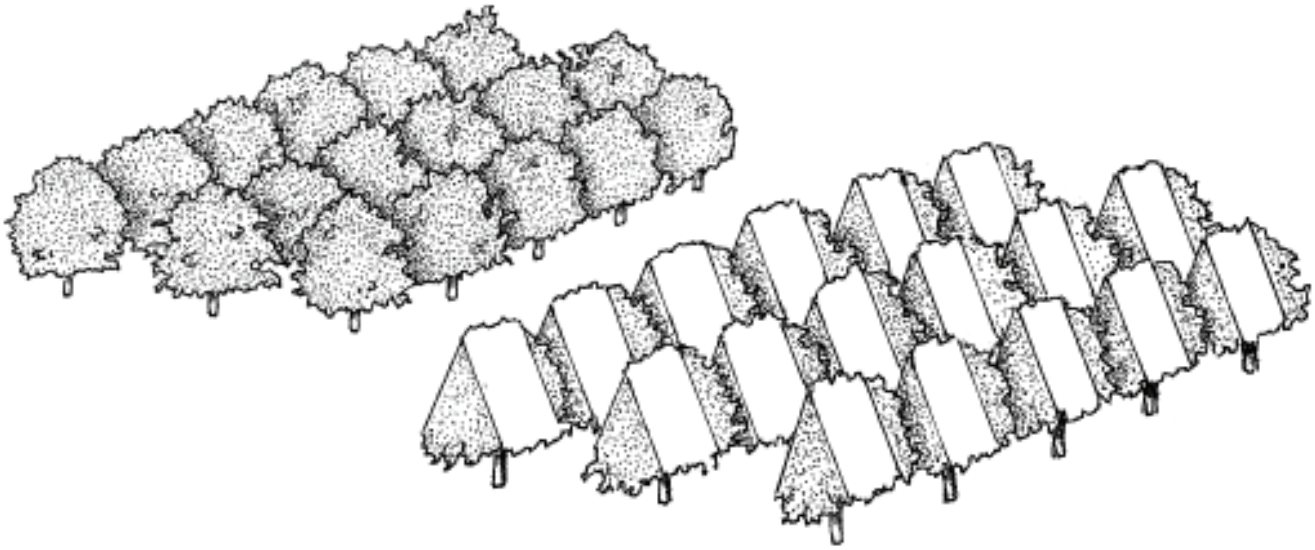


***Figure 26**. Desired result from hedgerow pruning. Upper: orchard before pruning. Lower: orchard after pruning*

more info
Hedgerow pruning
Section 4 page 62

More information on hedgerow pruning is in Section 4, *Key Issues*, but the basic steps are as follows:

1. Start shaping in the year before the first commercial crop of fruit is set or when tree growth first restricts the laneway between the rows to less than about 2 m.
2. Do the first major A-shape cut immediately after harvest in the autumn–winter months to minimise the risk of sunburn on exposed branches. Cut the foliage back to produce a laneway space of about 4 m. For example, in south-east Queensland, this is best done as soon as possible after harvest (about June–July for Hass).

   In southern production areas, where harvest is much later in the year during spring and summer, a major pruning after harvest could result in serious sunburn. In this case, a decision needs to made to sacrifice fruit in one year to enable the major pruning to be done in winter. Choose a light cropping year to minimise the loss.
3. If flowers are produced in the spring following a shaping cut, trees can be sprayed with the plant growth regulator uniconazole (Sunny®) at the registered rate. Uniconazole is applied to improve fruit size and retention and has the benefit of reducing the vigour of the spring shoot growth. **Only use on very healthy trees**, visibly free from root rot disease, with a full, deep green leaf canopy, and free from nutrient deficiencies and moisture stress.
4. Trim the A-shaped frame in late spring–early summer, removing about two-thirds of the spring leaf flush (up to about 20 cm of growth) after it has hardened (about November in south-east Queensland).
5. The summer flush is allowed to grow to produce the flowers for the next crop. Once the summer flush has hardened (about mid-March in south-east Queensland), a light trimming of the flush is useful in removing protruding shoots and maintaining the hedgerow shape.

   Cut close to the sloping 'platform' and at the same angle as the initial shaping cut. In most cases, trimming of the spring flush should do minimal damage to the fruit as they will generally be hanging further back within the canopy.

6. When the base of the hedgerow again starts to encroach into the 2 m wide laneway between the rows, repeat the major winter tree shaping cut. As it will reduce production in the subsequent season, it is best to stagger this major re-cut across the orchard.
7. Window pruning (selective removal of a single large limb from the side of each tree in the hedgerow) will be periodically required to prevent the development of a dense 'green wall' at the trimming face. The 'green wall' makes it difficult for light and spray materials to penetrate the canopy. Any water shoots growing from the spring–summer trimming can also be removed at this point.

Use of growth regulators to improve fruit size

An option exists to improve fruit size and shape through the use of the plant growth regulator, uniconazole (Sunny®). It can be particularly useful for Hass, where production of small fruit is an inherent problem. It is also of value for Shepard, where fruit shape and the evenness of ripening can be improved.

Sunny® works by reducing the spring leaf flush, thereby reducing competition with developing fruit.

However, there is one very important prerequisite for its use. Trees must be very healthy, as indicated by the following criteria:

- Visibly free from root rot disease with no more than 15% leaf loss at mid-bloom.
- Strong shoot growth in the previous summer, leading to a full, deep green leaf canopy by flowering time.
- Free from nutrient deficiencies with leaf nitrogen as measured in the previous April–May of at least 2.4% (Hass, Shepard) and 1.8% (Fuerte, Sharwil).
- Well irrigated and free from moisture stress.

If these tree conditions can be met, Sunny® can be applied at mid-bloom (when 50% of the flowers on the tree have opened) and before more than 10% of the spring shoots have begun to grow. The chemical is applied at a rate of 1 L/100 L of water with non-ionic wetting agent added at a rate of 50 mL/100 L of spray. The spray is applied to thoroughly wet the outside of the tree. As a guide, 3 to 4 L of spray is generally required to wet a tree of 4 m canopy diameter.

Harvest fruit as soon as they reach commercial maturity, otherwise flowering and fruit set may be reduced in the following season.

Weed control and mulching

more info
Weed control
This section page 20

Maintain the interrow grass sward and continue mulching and spraying for weeds as outlined under 'Managing Young Trees'. This keeps most weeds under control and minimises the use of herbicides.

As recommended under 'Root rot control', maintain a layer of mulch under and around trees to 0.5 m beyond the edge of the dripline until trees are able to provide their own natural deep litter mulch from natural leaf fall. Preferred mulches are coarse, fibrous materials such as wheat and barley straw, sorghum stubble and composted pinebark. Cane tops are also suitable

a key issue

Mulching
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but may cause a drop in soil pH. Where used, monitor soil pH carefully to ascertain whether extra liming materials are required. Where possible, avoid bagasse or sawdust (they remain too wet after rain and are hard to rewet when dry), and peanut husks (provide too much nitrogen and may introduce Verticillium wilt). Apply mulch to a depth of 10 to 15 cm in August. Keep mulch about 10 cm away from tree trunks. Renew mulch in December if roots are unprotected.

Use herbicides to kill any weeds that grow through the mulch and along the edge of the mulched area. Apply when the weeds are actively growing. Take care to prevent herbicide contact with any green part of the tree, particularly low hanging leaves. Minimise drift by using shielded, low-pressure fan nozzles. Also apply low volumes to avoid herbicides draining through the mulch and being absorbed by the roots.

Table 16 lists the preferred herbicides for use. A sound strategy is to use the knockdown herbicides such as paraquat or paraquat/diquat mixtures with the odd application of glyphosate or glufosinate-ammonium (Basta) to clean up any weeds that are difficult to control.

Glyphosate should be used with caution on the sandy soils in Western Australia as it may be taken up by the roots.

Table 16. *Herbicides preferred for use in bearing orchards*

Chemical	Weeds controlled	Products
paraquat	Most grasses and some broadleaf weeds	Boa Gramoxone Maxitop Nuquat Paradox Paraquat Shirquat Sprayquat Spraytop
paraquat + diquat	Most grasses and broadleaf weeds	Sprayseed Tryquat
fluazifop-P	Grasses only	Fusilade
haloxyfop-R	Grasses only	Appeal Asset Gallant West Typhoon Verdict
glyphosate	Grasses and broadleaf weeds	Glycel Glyphosate Ken-up Nomix Razor Sharp Roundup Sanos Touchdown Weedmaster Wipe-out
glufosinate-ammonium	Grasses and broadleaf weeds	Basta

Pollination management

Although cross-pollination between varieties is seldom if ever required for effective fruit production in Queensland, northern New South Wales and most of Western Australia, bees and other insects assist pollination within varieties. In colder areas such as Sunraysia–Riverland, where there is some mixed planting, bees and other insects are valuable in maximising effective cross-pollination.

Consequently, the introduction of bee hives into avocado orchards is recommended, particularly where the activity of native bees is low. Introduce two to four hives per hectare when 10% of flowers have opened. Place hives close to orchard blocks.

Where it is necessary to use insecticides during flowering, take precautions to prevent killing bees. Where possible, choose insecticides that do not harm bees. Particularly try to avoid using carbaryl during flowering. Spray late in the afternoon or at night, when bees are generally safe in the hives.

Windbreak maintenance

Deep rip at least every second year between the windbreak trees and the orchard to reduce competition for water and nutrients. Rip at least 2 m outside the edge of the tree canopy. If spreading foliage is reducing access to the trees, trim the sides of the windbreak trees. This also reduces competition for light. Avoid completely removing the lower limbs of the windbreak trees as this will reduce their effectiveness as a windbreak.

Harvesting and marketing

To turn out a quality product, you have to pay particular attention to eight important operations in harvesting and marketing.

Deciding when to harvest

Mature fruit do not ripen and soften on the tree. You must learn to judge when hard, green fruit is mature and ready for harvest. If an immature avocado is picked, it will not ripen to an acceptable eating quality and will often shrivel and develop fruit rots.

Mature avocados can be recognised by a dull appearance of the skin or shrivelling and yellowing of the fruit stalk. When the fruit is cut open and the seed removed, the seed coat is dark brown and dry, and does not adhere to the flesh. Large fruit on the northern and eastern side of the tree, and fruit at the top and outside of the canopy, usually mature first.

A minimum maturity standard of 21% dry matter is required for marketing avocados in most Australian states. However, fruit will be more palatable and have better flavour if allowed to reach dry matter levels 3 to 5% higher than the 21% level. The standard also requires that fruit must ripen without shrivelling and decay.

Check maturity before starting picking by doing a ripening test and a dry matter test.

Ripening test

For a ripening test, select 5 to 10 avocados from trees scattered throughout the block and representative of the fruit that may be ready for harvest. Sample sound fruit that show no sign of broken skins, insect stings or disease. Allow the fruit to ripen at room temperature and examine and taste the fruit when ready to eat. Mature fruit usually ripen within 7 to 12 days without shrivelling and have good flavour.

Dry matter test

The dry matter test involves weighing a sample of flesh before and after drying. The test can be done at home using a household conventional oven or a microwave oven. Alternatively, some marketing cooperatives and packing houses offer the service for a fee. Here are the details of the test.

WARNING

After the flesh is shredded and mixed, move IMMEDIATELY to the weighing step below. This avoids any moisture loss which may lead to incorrect dry matter calculations.

1. Sample preparation

- Select five to ten avocados that represent fruit you intend to harvest.
- Start the remainder of the process within a few hours of harvest.
- Cut each fruit longitudinally into quarters—stem end to base. Remove the seed as well as any adhering seed coat.
- Select two diagonally opposite quarters from each fruit to provide a total sample of 10 quarters. Peel the 10 quarters.
- Shred the flesh of all 10 quarters using a kitchen grater. Ideally the shreds should be less than 1 mm thick. This can be achieved using graters with five cutters per square centimetre.
- Thoroughly mix all of the shredded flesh together.

2. Drying procedure

Conventional oven

- Preheat oven to 100 to 110°C.
- Use a shallow, ovenproof container. Weigh the dry container and record this weight. Then spread at least 100 g of the shredded avocado evenly onto the container and weigh. Record this weight.
- Place the container in the centre of the oven and leave undisturbed for five hours. During drying, be careful to avoid burning the avocado flesh. Avoid or at least minimise opening the oven door during this period. An easily read oven thermometer is useful to monitor the actual oven temperature.
- After five hours, allow to cool and reweigh, to determine dried avocado weight. With initial tests, redry the sample for a further 30 minutes and then reweigh to ensure that the sample is fully dried.

HINT

A simple way to determine if the sample is fully dried is to take a shred of the dried flesh about 5 cm long, place it longitudinally between the thumb and forefinger and try to bend it. If it is brittle and snaps cleanly, it is fully dried. If it bends without snapping, more drying time is required.

Microwave oven

- Weigh a dry, shallow, microwave-proof container and add at least 100 g of shredded avocado and weigh. Record both weights.
- Set microwave at medium-low for 15 to 20 minutes. **Note: You may need to adjust power setting and time depending on the microwave**. Avoid burning the flesh. Dry to a constant weight. By reheating and reweighing, or using the 'snap' test (see clipboard at left), you can establish that the sample is fully dry. Note the time taken for future reference. When first trying the microwave method, keep a constant watch on the sample until you are confident of your settings. To avoid possible damage to your microwave, always place a container of water on the turntable.

3. Calculate percentage dry matter

Use the following calculation:

$$\frac{\textit{Weight of dried avocado sample (minus weight of container)} \times 100}{\textit{Weight of fresh avocado sample (minus weight of container)}}$$

There are no dry matter standards for over-maturity but this fruit should not be marketed. Do not leave fruit on trees beyond the normal picking period. Picking over-mature fruit results in poor flavour and an increased incidence of disease and flesh disorders, and reduces the yield of the next crop.

Harvesting and delivery for packing

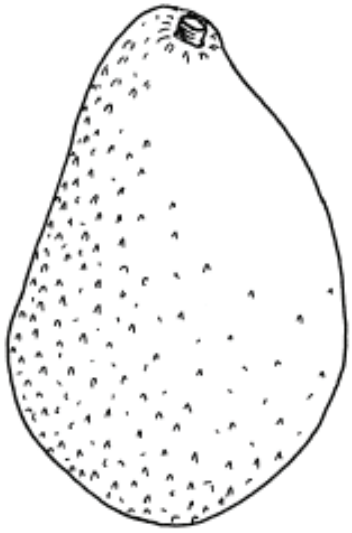
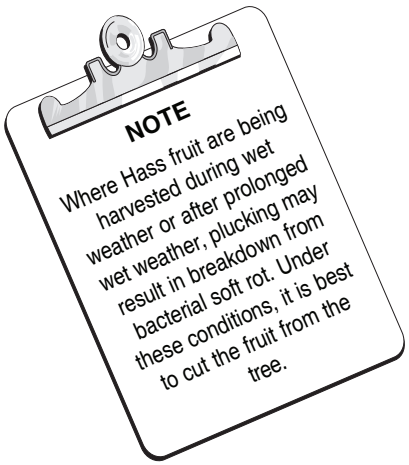


Figure 27. *Leave 3 to 4 mm of stalk when harvesting fruit*



Harvesting

- Avocados are picked by hand using ladders, picking poles and, where slopes permit, hydraulic picking platforms or cherry pickers.
- Avoid picking during wet weather, as fruit are more susceptible to skin damage and fungal infection.
- If fruit are to be cool stored for more than two weeks, avoid picking during extremely hot weather (above 35°C), as fruit are more susceptible to breakdown.
- Make sure pickers have sufficient knowledge of what is required—the correct block, variety, sizes and what fruit to reject.
- For all varieties other than Hass, cut the fruit from the tree using avocado snips, secateurs or shears, leaving 3 to 4 mm of stalk intact (Figure 27). Cut stems to the right length as longer stems can damage other fruit. For Hass, fruit can be plucked from the tree as long as the stalk is removed cleanly without tearing the flesh around the stem. If fruit is being marketed through a packing cooperative, check their requirements before proceeding.
- Several picks may be required. Remove large fruit first, allowing remaining small fruit to increase in size. Harvest at least 50% of fruit within one to two months of it reaching maturity. This is important where trees set heavy crops. Otherwise, trees may be pushed into an alternate-bearing pattern.
- To avoid damage, handle each fruit very carefully. Place fruit carefully and gently into picking bags and bins (crates). Don't overfill bags or bins (crates). Be careful not to puncture fruit with fingernails.
- Keep harvested fruit under shade.

Delivery to packing shed

- Transport picking containers carefully to the packing shed because the skin of freshly picked fruit is susceptible to impact and vibration damage. Damage to the 'pimples' (or nodules) on the skin can result in an unsightly spotted appearance.
- Cover loads to minimise heating of fruit, to prevent sunburn and to stop dust from entering the picking containers.
- Avoid excessive delays between picking and delivery to the packing shed. The maximum delivery time recommended varies with the length of the marketing period and the fruit temperature (Table 17).

Table 17. *Maximum time between picking and delivery to packing shed*

Marketing period (picking to retail shelf)	Maximum delivery time to packing shed	
	Fruit temperature *less* than 30°C	Fruit temperature *more* than 30°C
Less than two weeks	36 hours	12 hours
Two to three weeks	12 hours	6 hours
More than three weeks	3 hours	Do not pick

Handling in the packing shed

- On arrival at the packing shed, place field containers (crates or bins) under cover to prevent sunburn of the fruit and build-up of field heat.
- An assessment of fruit quality on arrival will alert the grading staff to any likely defects. Early picked fruit may require testing for maturity before being cleared for packing. The quality and maturity assessments can be recorded on a receival assessment sheet along with the number of field containers received.
- Cooling before packing may be necessary if delays are excessive.
- Tip field containers carefully onto the packing line. Avoid drop heights greater than 20 cm. The flesh of freshly picked fruit is particularly susceptible to impact and vibration damage and may shatter internally if dropped from greater heights. 'Pimples' or nodules on the skin can be damaged from abrasion or impact caused by poor handling.

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Cooling and storage
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Postharvest chemical treatment

For control of anthracnose and stem-end rot diseases, treat fruit within 24 hours of harvest with the chemical prochloraz. Apply it as a non-recirculated spray over fruit on rollers or brushes. Follow label directions. The volume of spray applied must be sufficient to thoroughly wet the fruit (at least 15 seconds under the spray). If exporting the fruit, check that the importing country approves of the prochloraz treatment.

It is important to note that postharvest treatment is not a substitute for field spraying—both are necessary to achieve **high quality fruit**. The performance of the prochloraz treatment is affected by:

- the level of anthracnose infection of the fruit at harvest;
- the type, length and temperature of storage and ripening to follow;
- the susceptibility of the fruit to disease development (for example, Hass on Duke 6 rootstock and Hass fruit with low calcium concentrations are more susceptible to anthracnose development with the result that the postharvest treatment may not work).

Fruit from some areas of eastern Austalia may need to be treated with dimethoate before shipment interstate. Fruit in Western Australia must be maintained in an approved secure manner to exclude Mediterranean fruit fly before entry into other Australian states. Treatment conditions are described in Interstate Certification Agreements (ICAs).

Record the details of postharvest treatments on a postharvest chemical treatment record. The record provides evidence that the treatment has been applied correctly and complies with food safety regulations.

HINT
The AVOMAN software provides an excellent method of recording details of postharvest treatments.

Grading and packing

Drying and polishing

Dry fruit before grading and packing by blowing air over it on rollers or brushes or by passing fruit through a heated drying tunnel. Check the operation of the drying tunnel to reduce the risk of any heat damage.

Fruit may be polished with brushes to improve presentation or to remove visible spray residues. Do not brush fruit for longer than one minute. Excessive brushing can cause abrasion injury, especially on Hass, resulting in an unsightly spotted appearance. Ensure brushes are of a suitable type for avocados and replace worn brushes as required.

Grading

Avocados are hand-graded for quality as fruit passes over rollers. All Australian markets expect fruit in a tray or box to be of one variety, sound (no broken skins from cuts or insect stings), clean, well formed, mature (at least 21% dry matter) but not over-mature, and of uniform size. Reject fruit not reaching this minimum standard.

Avocados are typically sorted into two quality grades. The quality standard for each grade depends on customer requirements. To establish quality standards for each grade, the maximum acceptable level (allowance) of various defects on individual fruit must be defined. The tolerances for out-of-grade fruit in packages must also be determined.

Fruit is graded for size using different types of measuring equipment: by diameter (expanding rollers or belts), weight (mechanical or computer) or volume (optical). The equipment is adjusted to achieve the range of sizes required for packing. The size classes are known as 'counts', on the basis of how many fruit of a particular size will fit into the standard package. The difference between the smallest and largest fruit in a pack should not exceed 5 mm in diameter. Size classes or 'counts' range from 12 to 28. Fruit smaller than count 28 is placed into bulk packages and net weight is used to indicate the amount of fruit in the package.

Packing

The standard package used for domestic and export marketing is a single layer tray holding a minimum of 5.8 kg of fruit (Figure 28). Inserts with moulded cups are used to aid packing. The inserts are available in a range of counts from 12 to 28 fruit per tray.

Each fruit is placed into a cup with stem-end up and locked against surrounding fruit. The smaller the fruit, the more vertical it is packed. Tight packs are essential to prevent fruit movement and rub damage during transport. Avoid over-packing to prevent pressure damage, particularly when fruit is ripening in the package.

***Figure 28**. A typical single layer tray of fruit ready for marketing*

Consignment No.		BIG GREEN ONES		Q. No:..... Date code:.....
Variety		AVOCADOS		Meets ICA number .....
Fuerte	✔	Count: 18	Grown and packed by: I. Growem Old Palmwoods Road PALMWOODS Q 4555	Consigned to: A. Wholesaler Stand 13 Sydney Markets
Sharwil				
Hass		Grade:		
Wurtz		No. 1 ✔ / No. 2 / Cocktail		

Figure 29. *Trade description on a package*

Fruit smaller than count 28 and second grade fruit are often packed into bulk packs, typically holding 10 kg of fruit. The bulk packs are volume filled and may contain fruit of even or mixed sizes.

For first grade fruit, small stickers are usually placed on each fruit. The stickers are used to enhance eye appeal and provide brand, region or variety identification. All major retail chains require PLU (Price Look Up) numbers to be placed on the fruit stickers.

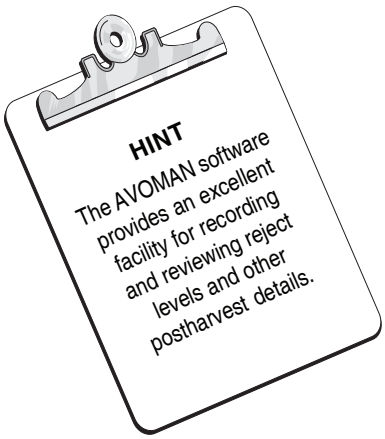
A trade description must be printed or stamped on at least one end of the package. The information must be prominent and indelible, with letters at least 5 mm high. The trade description must include the brand name, name and address of the packer, the word 'avocado', the variety, the grade or class and a statement of contents (count or net weight). An example of a package trade description is shown in Figure 29.

We recommend that product identification codes, such as grower number, block number, quality assurance codes, ICA codes and packing dates, are stamped on each package to enable traceback of product if there are problems during marketing.

Final product inspection

Final product inspections are carried out to check that the product meets specification. They also enable problems to be fixed before the fruit is marketed.

Representative samples of packed product are inspected throughout the packing period. Take the first sample within 15 minutes of starting packing and then at intervals of about one hour depending on packing shed throughput. Select packages without bias and across the range of fruit sizes. The sample should contain at least 50 fruit (two to three tray packs or one bulk pack).



Check that the labelling information on the package is correct and clearly displayed. Check fruit presentation, package weights and fruit sizing. Remove each fruit from the package and check whether it meets the quality standards.

Records of each inspection will help you make decisions and provide evidence on whether the product meets the specification. If it is outside the specification, corrective actions must be taken to fix the problem and prevent recurrence. Affected product must be isolated and a decision made to reject, downgrade, regrade, or redirect the product to another customer.

An inspection of reject fruit is also useful. It identifies the major reasons for rejecting fruit, as well as checking that grading staff are not over-grading. Interpretation of the reject analysis can identify where management procedures in the orchard can be improved.

Packing shed and staff hygiene

Hygiene is important to prevent contamination of the product with chemicals or microbes affecting human health. Here are some important guidelines:

- Clean packing line equipment and the shed floor daily and other equipment and facilities such as the cool room as required.
- Store packaging materials in a clean location away from busy areas. Spot check packages and inserts and discard if soiled.
- Use a baiting program to prevent infestation from mice and rats. Check empty packages left overnight and inserts before use for signs of mice and rat droppings.
- Do not allow domestic animals into the packing shed and prevent birds from roosting and nesting.
- Store chemicals in a clean, secure area away from fruit.
- Place reject fruit in crates or bins and discard away from the packing shed.
- Discard effluent (postharvest chemicals) according to environmental standards.
- Provide appropriate toilet facilities and train staff to personal hygiene standards. This includes no smoking, eating or drinking when handling fruit, washing hands thoroughly after going to the toilet and no handling of fruit if suffering from an infectious disease.

Cooling and storage

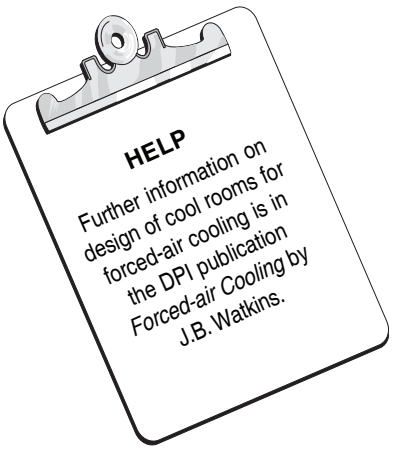
Cooling

Cooling is necessary to remove field heat and to lower fruit temperature to an appropriate storage or transport temperature.

In general, cool fruit if the period between harvest and delivery at the intended market is more than two days. This means that all fruit marketed outside the local area generally requires cooling. The general aim is to cool hard, green mature fruit to the following temperatures:

- Hass: 4 to 5°C
- Other varieties: 6 to 8°C.

In general, cool fruit to the required transport temperature within 48 hours of harvest. However, where fruit is to be stored for longer than five days, cool fruit to the required storage temperature within 24 hours of harvest. Always check with your marketers to ensure that on-farm cooling practices are compatible with market handling conditions.



Cooling requirements

The speed of cooling depends on the type of refrigeration system. Simply placing pallets or stacking packages into a cool room will result in slow and uneven cooling. Forced-air cooling is required to achieve fast effective cooling.

With forced-air cooling, an extra fan is used to pull cool air through the packages (Figure 30). Package ventilation must be designed to allow airflow

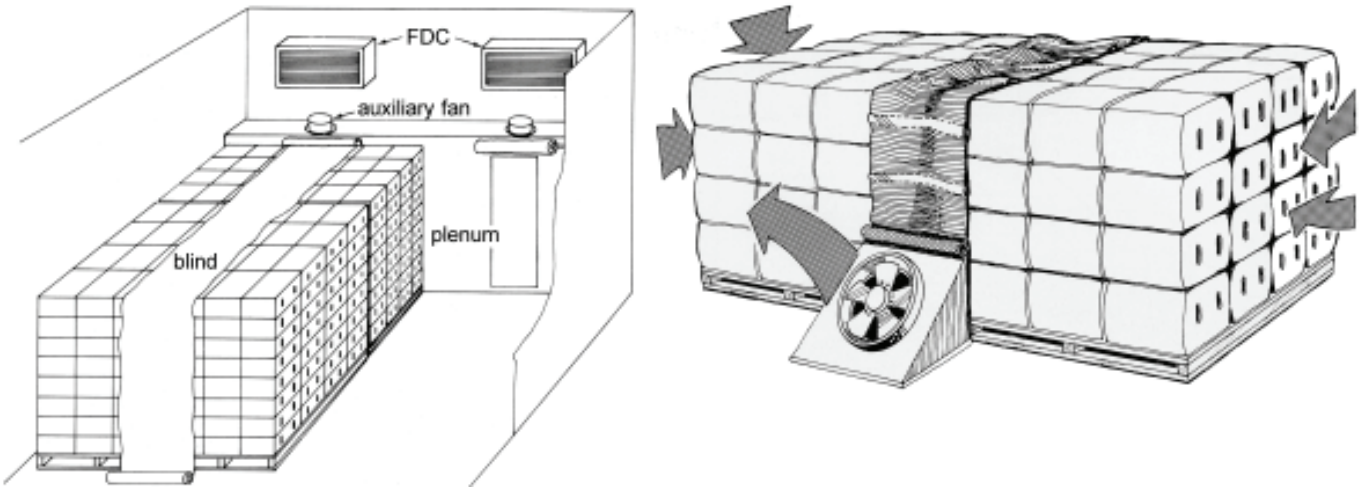


***Figure 30**. Forced-air cooling: left: fixed system; right: portable system*

across pallet loads. The speed of cooling is regulated through selection of the fan size (airflow). Cooling times faster than eight hours are not warranted as the resistance to airflow through packages is very high.

Monitor the cooling process to check that cooling has been effective. For forced-air cooling, check cooling times for each batch, check room temperatures daily, and spot check fruit temperatures at least weekly. A record of these checks will provide evidence of whether cooling has been effective and will enable tracebacks if there are problems during marketing.

Storage

Storage is the holding of cooled fruit before transport to customers (wholesalers, retailers, exporters).

The optimum temperature range and the maximum storage time for avocados varies with variety (Table 18).

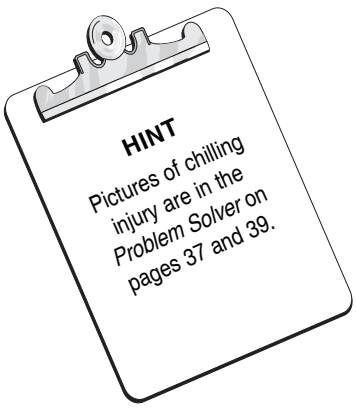
***Table 18**. Optimum storage temperatures and storage life for hard green mature fruit*

Variety	Optimum storage temperature	Maximum storage time
Hass	4 to 5°C	4 weeks
Other varieties	6 to 8°C	2 weeks

Storage life will be reduced by stress during growing; by picking fruit with advanced maturity; by delays in cooling after picking, particularly during hot weather; and by storage at temperatures above the optimum range.

Chilling injury of avocados during storage can occur in two situations:

- If fruit are stored at very low temperatures, such as 1 or 2°C. Symptoms appear as dark blotches on the skin.
- If fruit start to ripen during cold storage, because the storage temperature is too high and/or the storage duration too long. In this case, the symptoms are usually only present internally and develop as fruit ripens. Internal symptoms vary from dark streaks to grey-brown discolouration of the flesh, particularly around the base. External symptoms are not present except in Hass, where the skin may have a bronzed appearance when ripe and fail to develop the typical black skin colour.



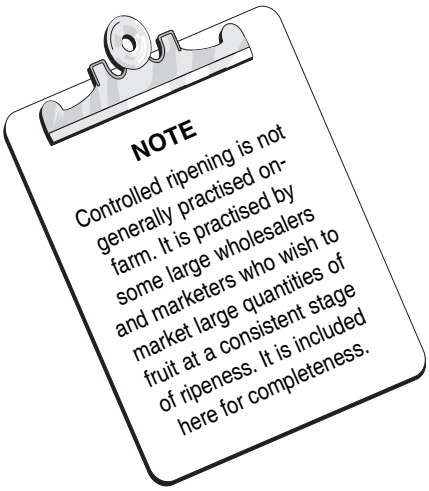
Daily monitoring of air and fruit temperatures is necessary to check the storage process. Keep a temperature log to provide evidence on whether storage has been effective. For long storage periods, check the fruit condition for any signs of ripening.

Avocados ripen quickly when they are removed from storage to normal air temperatures. For example, fruit removed from storage after two weeks and warmed to 20°C will ripen in about half the time as fruit held at 20°C immediately after harvest.

Controlled atmosphere (CA) conditions can extend the storage period for Hass. By reducing the oxygen level to 2 to 5% and maintaining the carbon dioxide level between 4 and 10%, a storage life of up to six weeks can be achieved. Specialised equipment and precise monitoring of the temperature and atmosphere is required. Only high quality fruit should be placed into CA storage.

Controlled ripening

Controlled ripening refers to holding fruit in a temperature controlled ripening room with ethylene (natural plant hormone) injected into the atmosphere. Controlled ripening reduces the variability in ripening that naturally occurs within packages, shortens the ripening time and reduces the incidence of fruit rots.



There are two methods for injecting ethylene into the cool room: shot and trickle. Ripening room construction, refrigeration and heating requirements, and air circulation within the room are similar for both methods. Ventilation of the ripening room is necessary to prevent a build-up of carbon dioxide, which will inhibit ripening.

For the shot method, ethylene is injected into the room two to three times each day. The room is ventilated before injection by leaving the doors open for 5 to 10 minutes. With the trickle system, ethylene is continuously trickled into the ripening room and inlet and outlet tubes in the wall provide continuous ventilation.

The recommended ripening conditions for avocados are:

- Temperature: 16 to 20°C
- Relative humidity: 90 to 95%
- Ethylene concentration: 100 ppm (shot method); 10 ppm (trickle method)
- Ethylene duration: 48 hours (early pick); 24 to 48 hours (middle pick); 12 to 24 hours (late pick)
- Carbon dioxide level: below 1%.

Good temperature management is critical to the success of controlled ripening. Avocados should be cooled (or warmed) to the ripening temperature and then held at this temperature until the fruit is sprung (first detectable softening).

Ripening temperatures between 20°C and 30°C favour development of fruit rots and the ripening rate is greatly accelerated, resulting in a high risk of over-ripe fruit. At temperatures above 30°C, ripening is inhibited.

Monitor and record the ripening times and temperatures to check the effectiveness of the ripening process.

Avocados take one to two days following the ethylene treatment to reach the sprung stage and then another two to four days to reach eating ripe. Near ripe fruit can be stored for up to 10 days at 2 to 5°C, except for Shepard, which is more susceptible to chilling injury. Near ripe fruit of Shepard can only be stored at 7°C for a maximum of five days.

Care must be taken when handling ripened fruit as susceptibility to bruising greatly increases as fruit ripens. Ripe fruit bruise at a drop height of 25 mm and sprung fruit at 50 mm.

Transport and marketing

Transport

For domestic markets, fruit is usually transported to markets by road.

For domestic transport, the single layer tray pack is stacked eight packages per layer on the Australian standard pallet (1165 mm x 1165 mm), to a height of 16 to 18 layers. (Figure 31). The 10 kg bulk pack is stacked 12 packages per layer to a height of eight to nine layers.

For maximum stacking strength, stack packages in columns rather than cross stack. Secure pallet loads with corner angles and horizontal strapping or tension net.

Wherever possible, stack different quality grades on separate pallets and stack counts or fruit sizes with the same PLU number together on the same pallet. Place a card on each pallet with details of the number of packages of each quality grade and count or fruit size.

Refrigerated transport is required for avocados in most situations. Uncontrolled ripening of fruit during transport must be avoided. Cooling fruit to the transport temperature is essential before loading. The cooling systems on transport containers do not have the capacity to significantly reduce the temperature of the fruit.

For domestic marketing, the acceptable temperature range for transport of Hass is 5 to 10°C and for other varieties 7 to 10°C. An exception is when fruit is being ripened immediately on arrival and the transport time is less than 24 hours. In this situation, transport fruit at 16 to 20°C.

Select transport operators that follow the AUF Code of Practice for Road Transport of Fresh Produce. This includes monitoring temperatures before, during and after transport.

For export, avocados are transported by air or sea. For airfreight, fruit are transported under non-refrigerated conditions either stacked on airline pallets or in containers. For seafreight, avocados are transported in refrigerated containers, either stacked on pallets or floor stacked.

For seafreight, transport fruit at the optimum storage temperatures specified in the previous section. For transport times longer than three weeks, controlled atmosphere conditions should be used.

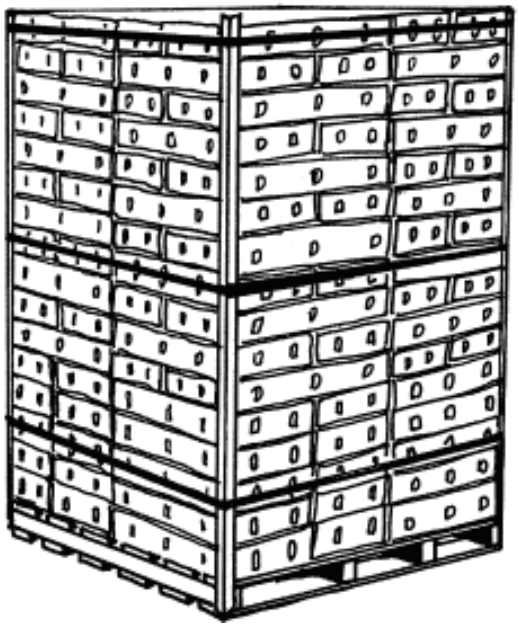


***Figure 31**. Pallet stacking arrangements*

Marketing

There are several options for marketing your fruit. Here are the main ones.

- **Domestic capital city produce markets**. Most avocados are sold fresh in major capital city produce markets. Fruit is consigned to either wholesale agents who sell fruit on commission and keep a percentage of the proceeds, or to wholesale merchants who buy fruit at an agreed price. Most fruit is consigned to the Brisbane, Sydney, Melbourne, Adelaide and Perth markets. Wholesale agents and merchants are an important source of market intelligence. For this reason, the choice of a wholesale agent or merchant is extremely important. It is best to deal only with a specialist avocado wholesaler. Seek advice on selecting wholesalers from local growers in your area.

  Market authorities in each wholesale market have booklets covering market times and rules, along with a list of agents and merchants operating in their market. Remember that you must meet the quarantine requirements defined by each state.

more info
Marketing groups
Section 6 page 10

- **Marketing groups or cooperatives**. Join a marketing group or cooperative where fruit may be jointly packed and marketing decisions are made on a group basis. This is highly recommended as the combined resources and volume of product allow a greater range of marketing opportunities.
- **Sell direct to major city supermarkets, chain stores and fruit barns.** These outlets need a regular supply of uniform quality fruit. This is generally only an option for very large farms or marketing groups.
- **Local supply.** In the more populated areas, you may wish to organise direct supply to local district retailers. This can be time-consuming work and the costs of organising sales and distributing fruit need to be carefully considered. There is also the possibility, though limited, of direct supply to resorts and restaurants. Where you have a high traffic flow, you can also sell fruit on the farm or at a roadside stall.

more info
Exporting
Section 4 page 27

- **Export.** Export has complex and specialised requirements and is normally only attempted by large growers, marketing groups or cooperatives. It requires strict attention to quality standards and quarantine requirements. Seek the advice of exporters or export market consultants before proceeding.
- **Processing.** This is only a small outlet at this stage, geared towards handling fruit that does not meet fresh fruit market standards.

Whatever market outlet you choose, keep in close contact with your marketer and ask for feedback on the quality of your fruit. Regularly visit the major markets in which your fruit is sold. Be prepared to become involved in the promotional activities of your avocado grower group.

Food safety requirements

Recent outbreaks of food poisoning have heightened consumer concerns about food safety. Unlike quality, the safety of food cannot be determined by looking at the produce. As a result, some retailers and wholesalers servicing them, want to see evidence that farm practices minimise the risk of contamination by excessive chemicals, harmful microbes and foreign objects.

The supermarket chains now require any business that supplies them directly to implement an independently audited quality assurance (QA) system incorporating Hazard Analysis and Critical Control Point (HACCP). Wholesale agents who supply the supermarket chains have put these QA systems into place.

a key issue

Quality management
Section 4 page 29

If your wholesaler or marketing group sells your produce to supermarket chains and food service buyers (caterers, restaurants, processors), they will require you to implement a food safety program to become an approved supplier.

A national on-farm food safety program called Freshcare has been developed to link food safety on farm to the approved supplier programs of wholesalers and marketing groups. Accreditation to Freshcare is achieved through an independent audit on farm for compliance with the Freshcare Code of Practice.

If your produce is sold to retailers who don't have specific requirements for food safety, you may not have to do anything extra, at least for the present. Some buyers want assurance that produce doesn't contain excessive pesticides. If your produce is sold to these buyers, your wholesaler may require you to keep spray records and to send them a copy.

If you sell direct to a supermarket chain, you will be required to implement a QA system incorporating HACCP and covering both food safety and product quality.