Persimmon information kit

Reprint – information current in 2005

REPRINT INFORMATION – PLEASE READ!

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This publication has been reprinted as a digital book without any changes to the content published in 2005. We advise readers to take particular note of the areas most likely to be out-of-date and so requiring further research: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- Financial information—costs and returns listed in this publication are out of date.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.deedi.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 2005. 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 persimmon production. 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.

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Queensland Government

Nutrition and fertilising

Plant nutrition is one of the keys to achieving good orchard performance. Both deficiencies and excesses of plant nutrients can adversely affect fruit yield and quality. Fertiliser use must be carefully managed to ensure a balanced supply of all nutrients is maintained at the critical times during leaf growth and fruit development.

Why nutrition needs to be carefully managed

Applying fertilisers without knowing the levels of nutrients in the soil and plants can result in nutrient excesses, deficiencies or imbalances. This can cause several problems including:

- reduced yields
- excessive shoot vigour, resulting in lower fruit quality
- contamination of groundwater from excess nutrients being leached out of the root zone.

Fertiliser needs vary according to tree variety and soil type. A blanket rate of fertiliser application does not take into account these different needs.

Nutrient levels in both the soil and plant need to be carefully monitored to improve yield and fruit quality, reduce fertiliser cost and reduce environmental effects.

The managed approach—monitoring

The modern approach to fertilising relies on regular monitoring of soil and plant nutrient levels so that nutrients are kept at optimum levels for the plant. Three different monitoring tools are used:

- Pre-plant soil analysis ensures that the soil is suitable for the crop and that nutrients are at their optimum levels before planting. Pre-plant analysis is particularly important because it allows insoluble nutrients such as phosphorus and calcium to be incorporated before trees are planted. Both these nutrients are difficult to adjust once the trees are in the ground.
- Annual leaf analysis in bearing trees allows the fertiliser program to be fine-tuned each year. It allows variables such as season, crop load and condition of trees to be taken into account.
- Regular (preferably annual) soil analysis in bearing trees ensures that soil pH is kept within the desired range and monitors the important balance between pH, calcium, magnesium and potassium.

Understanding sweet persimmon nutrition

Poor fruit quality (small fruit and poor post-harvest storage life) has been identified as a major problem for the Australian sweet persimmon industry. Few studies have evaluated the effects of nutritional practices on fruit size or other quality variables such as colour or storage life.

In 1997, the Persimmon Industry Association Incorporated (PIAI), the Australian Persimmon Export Company (APEC), Queensland Fruit and Vegetable Growers (now Growcom) and Horticulture Australia Ltd. jointly funded a research project titled Nutritional management of non-astringent sweet persimmon. The purpose of this project was to improve the yield and overall fruit quality of sweet persimmon by optimising tree nutrition. The results have been used in writing this handbook.

Soil pH

Soil acidity or alkalinity is measured on a pH scale of 0 to 14, with 7 being neutral; below 7 the soil is acid and above 7 it is alkaline. The pH scale is a logarithmic scale; soil with a pH of 5 is 10 times as acid as a soil with a pH of 6.

In Australia, soil pH is usually measured either in water or in a dilute calcium chloride solution. The value measured with calcium chloride is usually about 0.7 units below the water value. For example, a calcium chloride pH value of 5.0 corresponds to a water value of about 5.7.

Commercial soil testing laboratories express soil pH results according to the testing procedure used, either as a 1:5 water test or 1:5 $CaCl_2$ test. As the test results are interpreted differently, it is important to know which test has been used. Throughout this book, soil pH results are expressed using the 1:5 water test, for example pH 5.5 (1:5 water test).

If soil is too acidic, a complete soil analysis will show whether lime or dolomite is the most suitable remedial treatment. While dolomite contains calcium and magnesium, lime contains calcium only. Lime and dolomite are highly insoluble and should be applied as early as possible—at least six months before planting—and properly incorporated into the topsoil.

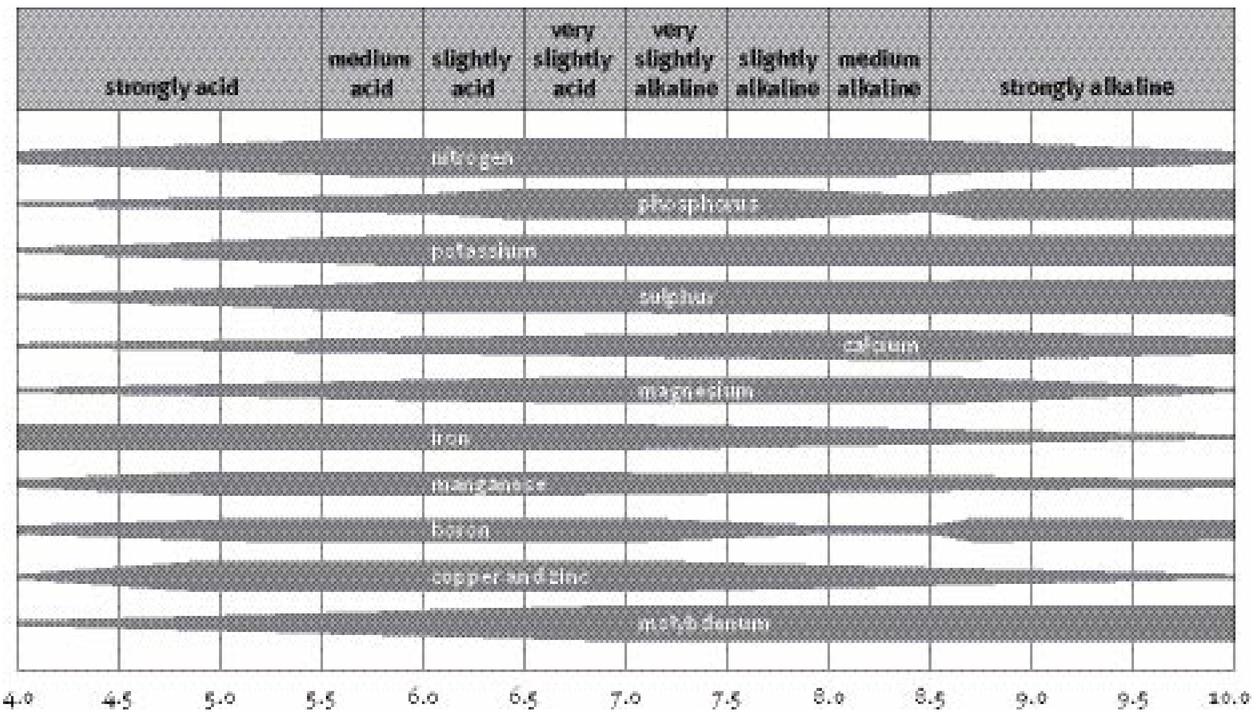


Figure 83 Effect of pH on nutrient availability

At low soil pH, aluminium, iron and manganese may be present at toxic levels. This is intensified if the soil is waterlogged or has low organic carbon levels. Nutrients such as molybdenum are only slightly available to plants below a pH of 6.0. On the other hand, soil pH above 6.5 reduces the availability of trace elements such as boron, copper, iron and zinc (Figure 83).

Fertilising bearing trees

Trees grown in a subtropical climate and entering their third or fourth year can carry a commercial crop, providing they have grown well. A bearing orchard requires different fertiliser rates.

The five major nutrients required will be nitrogen, phosphorus, potassium, calcium and magnesium. Specific practices may vary in other areas depending on soil type. Nitrogen, phosphorus and potassium should be applied based on soil and leaf tests.

The amount of fertiliser applied to an orchard can be based on:

- previous fertiliser history
- crop removal rates for different nutrients, that is the amount removed by the fruit, leaves and prunings
- the amount of nutrients leached through the soil profile or washed from the soil surface
- the amount of nutrients unavailable in the soil due to fixation
- recent leaf and soil analysis data
- visual leaf nutrient symptoms and tree growth.

Crop removal of the major nutrients such as nitrogen, phosphorus, potassium, calcium and magnesium can be calculated; it takes into account all nutrients exported from the orchard in leaves, prunings and fruit.

Nutrient leaching losses

Heavy rainfall, irrigation and runoff can leach valuable nutrients from the soil. Normally, leaching is greatest in light-textured sandy soils with little clay and low organic matter.

The amount of nutrients lost because of leaching is difficult to estimate because of variations in soil type and weather conditions.

Some limited data for losses in sweet persimmon orchards is provided:

- up to 70% of applied nitrogen and potassium can be lost by leaching
- up to 50% of the phosphorus applied could become unavailable to plants by fixing or leaching.

The figure for phosphorus depends on soil type. In sandy shallow soils (e.g. podzolic soils), 75% of applied phosphorus may become unavailable to plants; in deep red soils (e.g. krasnozems), 95% could become unavailable. The phosphorus requirements of sweet persimmon are low and the probability of a deficiency is remote. Incorporating phosphorus into the soil profile before planting assures its availability over a long period.

Nutrients supplied by fertilisers can also be lost to the atmosphere. For example, if urea or animal manure-based fertilisers are not incorporated into the soil by either cultivation or watering, then significant amounts of ammonia can be lost.

Fertiliser rates

Crop nutrient removal rates are often used to develop a basic fertiliser schedule for tree crops. However, using crop removal rates without allowing for losses by leaching and other causes severely underestimates the amount of fertiliser required for maximum yields for most soil types. In some highly fertile soil types such as krasnozems, nutrient crop removal rates plus a smaller allowance for leaching (30% or more) are adequate.

Research conducted at Gatton and Nambour in Queensland by DPI&F suggest that the optimum rate of nitrogen application is 90 kg/ha and for potassium, 120 kg/ha.

Fertiliser timing

It is best to apply nitrogen at a very low rate at bud break and follow this by a higher rate application in mid-summer. Excessively heavy applications before fruit set increase fruit drop.

HINT

Based on both Australian and Japanese studies, we recommend that the annual nitrogen, phosphorus and potassium fertiliser requirement be split into three applications.

The timing of potassium fertiliser application appears to be less critical; however, on low calcareous soil types, heavy potassium applications at bud break and during fruit set may displace calcium uptake during its period of maximum absorption. Three applications should be applied as follows:

- 20% applied at bud break
- 60% in mid-season (late December/early January)
- 20% during mid-harvest.

Applications of nitrogen and potassium during late harvest should not adversely affect fruit quality, but will maintain leaf health and prevent premature defoliation. Premature leaf drop reduces the build-up of starch reserves for the next season's crop.

Table 18 New fertiliser rates and timing for Australia

Nutrient	Fertiliser rate (kg/ha)[1]			Total rate per year
	Bud break	Late December/early January	Mid-harvest	
Nitrogen	18	54	18	90
Phosphorus	3	9	3	15
Potassium	24	72	24	120
Calcium	150	–	–	150
Magnesium	14	42	14	70

[1] These fertiliser rates are an average rate and will require further adjusting for different soil types and leaching rates. Adjustments should be based on leaf and soil analyses.

Fertiliser types

Organic fertilisers

The use of organic fertilisers is encouraged during orchard establishment to:

- increase soil organic matter levels
- improve soil physical structure
- increase water storage
- increase nutrient availability
- suppress disease organisms through increased microbial activity.

The nutrient release rates for organic matter are lower than for manufactured fertilisers. We suggest that deep-litter fowl manure be stored for one to two months before spreading to allow some decomposition. It should be stored under cover to prevent wetting and leaching of valuable nutrients such as nitrogen and potassium. Caged fowl manure may be an alternative.

Mill mud, a by-product of sugar cane milling, is generally available to orchards in subtropical and coastal districts. Beware of weed seeds which may be moved into orchards with this mix.

Losses of ammonia to the atmosphere can be high from fertilisers containing nitrogen in the ammonium form. These include natural organic fertilisers, particularly those derived from fowl manure, urea and ammonium nitrate.

These fertilisers should be rapidly incorporated into the soil where they will be transformed to nitrate. The greatest losses occur when organic fertiliser is applied to the top of the soil and periodic light rain wets the fertiliser, but is insufficient to wash the soluble nitrogen into the soil. A layer of plant mulch over fowl and other animal manures will reduce these losses.

Organic fertilisers generally have low levels of nutrient and application rates should be adjusted for this. Extra nitrogen and potassium will be required. The composition of some commonly used organic fertilisers is shown in Table 19.

Table 19 Composition of commonly used organic fertilisers

Source	Nitrogen (%)	Phosphorus (%)	Potassium (%)
Fowl manure (cage)	2–9	2–3	0.5–2.7
Fowl manure (deep litter)	2.0–7.0	2.5–3.5	1.5–2.5
Poultry pellets	3.5	2.5	1.7
Blood and bone	4	4	–
Cow manure	0.5–1.0	0.1–0.3	0.4–0.5
Sheep manure	0.9–1.8	0.3–0.4	0.3
Horse manure	0.6–0.7	0.1–0.3	0.4–0.6
Pig manure	0.5–0.6	0.1–0.6	0.3–0.4
Mill mud	0.5	0.2	0.04
Sawdust	0.01	0.01	0.007

Inorganic (manufactured) fertilisers

Some inorganic fertilisers contain a single nutrient, while others contain a mixture. Single-nutrient fertilisers are less expensive than mixed fertilisers. Mixed fertilisers (N:P:K) are convenient to use, particularly in non-bearing trees. However, continued use of these fertilisers may result in a build-up of phosphorus and create a nutrient imbalance. Some manufacturers add trace elements to their mixes, but the amounts are often inadequate to correct deficiencies.

Selecting the best fertiliser

Before selecting a fertiliser, the following should be considered: soil type, nutrient status, pH, amount and form of fertiliser required, and cost.

HINT

In wetter sandy soils, frequent applications of small amounts of fertiliser are recommended.

Soil type

Light sandy soils have a low nutrient-holding capacity and nutrients leach readily, so slow release fertilisers or frequent applications of small amounts of fertiliser are recommended. A clay soil can hold more nutrients and will not leach as readily as a sandy soil.

Nutrient status and pH

A soil test will provide valuable information on pH, nutrient levels and balance, and salt levels. Leaf analyses can be useful in assessing the general plant nutrient status and trace element requirements. This information, combined with observations on tree health, leaf symptoms, tree growth and yield, can be useful in developing a fertiliser program.

Fertiliser formulations

Because sweet persimmons are sensitive to chloride ions, the chloride form of potassium (muriate of potash) should not be used.

Little information is available on whether sweet persimmons prefer to take up nitrogen in the ammonium (NH_4^+) or nitrate (NO_3^-) ion form (Table 20). To maintain a balance with calcium, it may be better to use the more expensive calcium nitrate rather than other formulations of nitrogen.

There is some Japanese evidence that suggests it may be better to use slow-release complete fertilisers at bud break rather than straight fertilisers, as the latter may promote excessive growth during fruit set.

Table 20 The approximate percentage of total nitrogen and nitrogen form in the most commonly used nitrogen fertilisers[1]

Nitrogen source	Percentage of each form of nitrogen		
	Ammonium nitrogen	Nitrate nitrogen	Total nitrogen
Ammonium sulphate	21	–	21
Ammonium nitrate	17	17	34
Calcium ammonium nitrate	13.5	13.5	27
Mono-ammonium phosphate	11	–	11
Di-ammonium phosphate	18	–	18
Calcium nitrate	1.5	14	15.5
Potassium nitrate	–	13	13

[1] Urea is in a special category and can break down into ammonium and nitrate ion forms depending on soil type

Leaching and volatilisation losses

More soluble fertilisers and formulations are highly susceptible to leaching, which can remove 70% of the fertiliser applied. More frequent, smaller applications of fertiliser (e.g. fertigation) reduce leaching losses.

Some nitrogen fertilisers such as urea can lose up to 80% of their nitrogen to the atmosphere (volatilisation), particularly on high pH soils, with losses of 40% to 50% more common. These types of fertilisers are not recommended for sweet persimmon.

Acidification

There are many forms of fertilisers available for a particular nutrient. When deciding which to use, consider whether the fertiliser will contribute to soil acidity or salinity, or whether it has the potential to pollute the environment. If your soil is acid, choose the least acidifying fertiliser available, or be prepared to add lime.

Nitrogen fertilisers have the potential to acidify the soil, with some having a greater acidifying effect than others.

Table 21 shows the acidifying effect of various fertilisers by calculating the amount of lime required to readjust the soil pH to its original value.

Table 21 Lime required to check soil acidification after applying the equivalent of 1 kg of nitrogen[1]

Acidification rating	Fertiliser	Lime requirement (kg)
Severe	Ammonium sulphate Mono-ammonium phosphate	5.4 3.5
Moderate	Di-ammonium phosphate	1.8
Slight	Urea Ammonium nitrate Potassium nitrate	1.8 1.8 2.0
Alkaline	Calcium nitrate	–1.35

[1] Sulphate of potash, muriate of potash and superphosphate have little effect on soil acidification.

Fertiliser placement

Mature tree roots extend into the middle of the row, so the whole orchard should receive some fertiliser. Set up the fertiliser spreader to place most of the fertiliser under the tree canopy.

Fertigation

Fertigation, the application of fertiliser through the irrigation water, is recommended and has many advantages over the manual application of solid fertilisers. It uses less labour, nutrient uptake is more efficient and fertilisers can be applied more regularly and conveniently. With efficient fertigation, annual rates of nitrogen and potassium application can generally be reduced by up to 25%.

Solubility

As long as the irrigation system is suited to fertigation and has a suitable injection unit and a good filtration system, the choice and mixing of fertilisers will depend on solubility and compatibility (Table 22). Do not add too much of any one product at any one time. The most suitable forms of fertiliser to apply through the irrigation system are nitrogen (calcium nitrate and potassium nitrate); potassium (potassium sulphate); and phosphorus (di-ammonium and mono-ammonium phosphates).

Table 22 Typical solubility of a range of products in water at 20°C

Product	Practical solubility (kg/L)
Ammonium nitrate	1.92
Ammonium sulphate	0.75
Calcium nitrate	1.29
Di-ammonium phosphate	0.65
Liquifert K	0.3
Liquifert K Nitrate	0.3
Liquifert K Spray	0.1
Liquifert Lo-Bi	0.3
Liquifert N	0.3
Liquifert P	0.4
Magnesium sulphate	0.33
Potassium chloride	0.34
Potassium nitrate	0.32
Potassium sulphate	1.11
Sodium borate	0.25
Urea	1.19
Zinc sulphate	0.54

Compatibility

Some combinations of fertilisers can lead to the formation of insoluble deposits (precipitates) that can block equipment. Some examples of combinations forming precipitates are:

- phosphate added to calcium nitrate, magnesium sulphate or to hard water with a high calcium or magnesium content
- non-chelated micronutrients such as copper, zinc, iron and manganese sulphate added to phosphates. Chelated products prevent minor nutrients from reacting with other salts; however, they are not completely stable (e.g. at high concentrations iron chelate will precipitate phosphate)
- sulphates added to a solution containing calcium (e.g. magnesium sulphate combined with a calcium nitrate solution results in a calcium sulphate precipitate forming).

Successful fertigation

Before you begin fertigation, have your irrigation water analysed by a water-testing laboratory. Make sure an iron test is included. Seek professional advice from an experienced irrigation designer when planning the system. Also consider the following:

- Fertiliser can be provided at different frequencies, either daily, every other day, several times each week or weekly, depending on irrigation needs, soil type and other factors. On very sandy soils, more frequent fertigation will be necessary.
- When dissolving the fertiliser add small amounts to allow the product to dissolve properly.
- The fertiliser tank should have its own filter to prevent large particles from entering the irrigation system and causing blockages.
- The fertiliser solution is introduced into the irrigation system using a venturi, an injection pump or pressure differential.
- The fertiliser must be injected into the irrigation system during the last third of the irrigation time to ensure leaching does not occur and that the correct fertiliser dose is given to each tree.
- It is best to divide fertiliser rates into many applications for the most efficient nutrient uptake. Fertiliser rates must be reduced; nitrogen rates can be reduced by up to 50% and potassium rates by up to 25%.
- Leaf analysis is needed to determine correct fertiliser rates.
- Several suitable commercial soluble fertilisers that supply a range of nutrients are also available. These include Flowfeed and Liquifert.

Nitrogen (N)

Function

Nitrogen is one of the most important nutrients. It controls growth and fruiting in plants, and is a constituent of plant proteins, enzymes and cell membranes, as well as plant growth hormones and chlorophyll. Most of the nitrogen potentially available to plants is contained in the soil organic pool.

Symptoms

When nitrogen is deficient, plants grow slowly, which can lead to a uniform pale green colour in most leaves. Trees with adequate nitrogen have dark green leaves and are vigorous.

Fruit yield

Nitrogen is a key manipulator of yield and quality. Excessively low or high rates of nitrogen application will reduce yield due to poorer fruit set and increased fruit drop (Figures 84 and 85). Yield is highest when low rates of nitrogen are applied at bud break, followed by higher rates in January. This fertiliser timing coincides with the major uptake period for nitrogen found in Japan.

Fruit quality

Excessive nitrogen can also reduce fruit sugar concentrations and storage life by 30% to 40% (Figure 86). The critical leaf nitrogen concentration one month before harvest is less than 2.5%, and ideally between 1.8% and 2.2%. Fruit firmness may also be adversely affected by increasing applications of nitrogen (Figure 87).

Storage life

Increasing rates of nitrogen can decrease the storage life of fruit, particularly for fruit grown on low calcareous, highly leached, sandy, coastal soil types such as podzolic soils (Figure 88). Leaf nitrogen concentrations greater than 2.2% greatly reduce storage life (Figure 89).

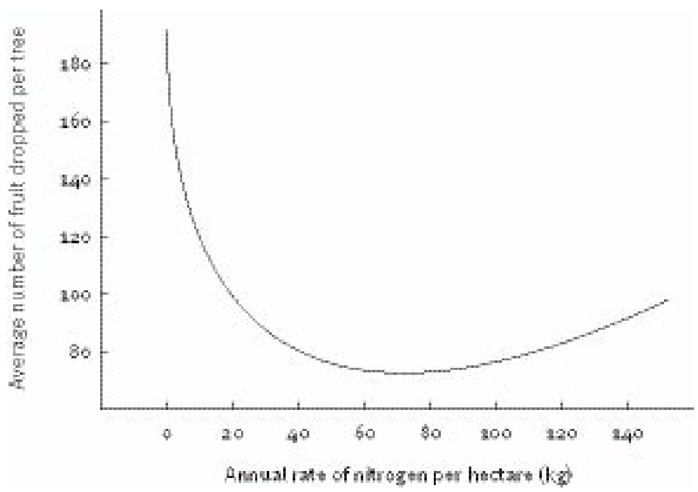


Figure 84 Effects of soil-applied nitrogen on average number of fruit dropped per tree

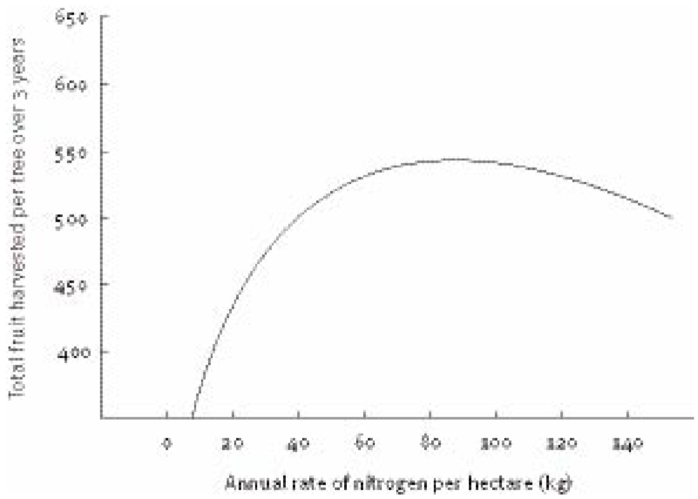


Figure 85 Effects of soil-applied nitrogen on total number of fruit harvested per tree over three years

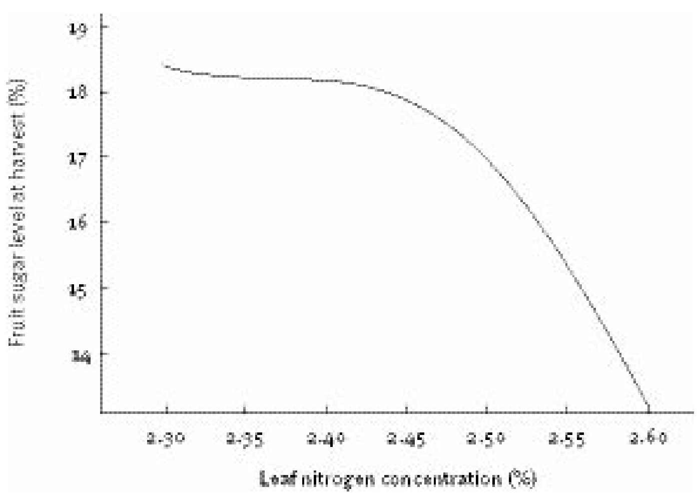


Figure 86 Relationship between leaf nitrogen concentration one month before harvest and fruit sugar concentration at harvest

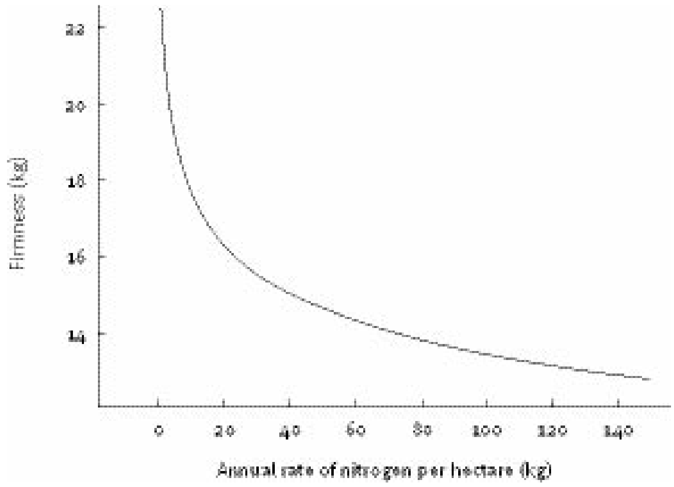


Figure 87 Effects of soil-applied nitrogen on fruit firmness

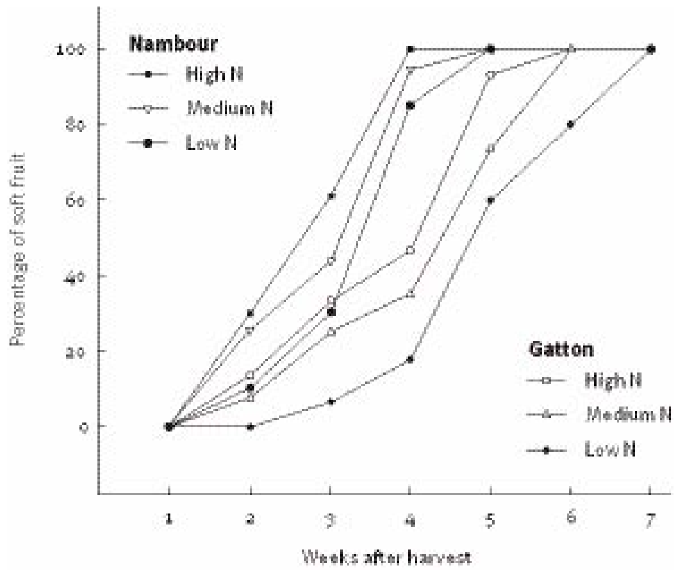


Figure 88 Effects of soil-applied nitrogen on storage life at 21°C of non-astringent persimmon cv. Fuyu at Nambour and Gatton, Queensland in 2000. Gatton has highly calcerous soils compared with Nambour, which has highly leached podzolics

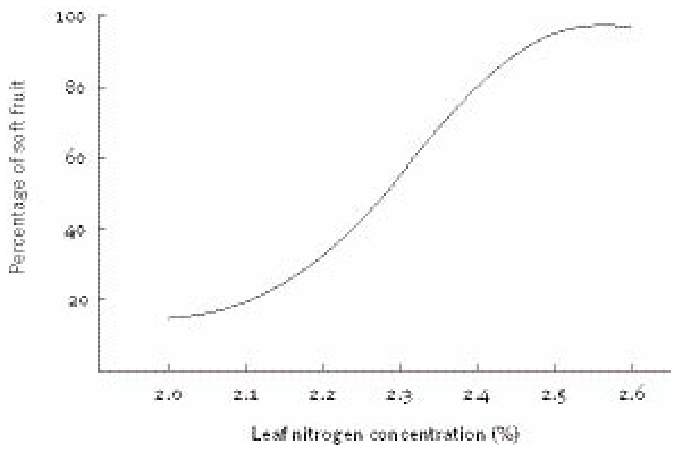


Figure 89 Relationship between leaf nitrogen concentration one month before harvest and percentage soft fruit stored at 21°C

Optimum rate of nitrogen application

The optimum annual rate of nitrogen application is about 80 to 90 kg/ha. Higher rates result in slightly larger fruit, but yields are reduced due to increased fruit drop. In addition, fruit sugars, fruit firmness and storage life are all reduced. A balance must be reached between increasing fruit size and decreasing fruit quality.

In the export market, price is largely determined by fruit quality, with fruit breakdown and softening greatly reducing price.

Optimum leaf nitrogen range

The optimum leaf nitrogen range one month before harvest is 1.8% to 2.2%. If leaf nitrogen concentrations are greater than 2.5% before harvest, fruit quality is adversely affected. The leaf calcium:nitrogen ratio and the leaf calcium:potassium ratio should both be greater than 1.5:1, one month before harvest.

Phosphorus (P)

Function

Phosphorus is an essential component of some fats, proteins and sugars. It is involved in plant photosynthesis and respiration, root growth, and flower and fruit development. Plant roots can absorb phosphate from very low soil solution concentrations.

Symptoms

Phosphorus deficiencies lead to poor root development, stunted growth and delayed maturity. Initially foliage is dark green. Older leaves then show bronzing or tanning of the upper surface, or purple-red pigmentation that intensifies in cool weather.

The oldest leaves may develop a mottled appearance before early leaf fall. New leaves are narrow. Phosphorus deficiency, however, is rarely seen in sweet persimmons.

High levels of phosphorus may cause zinc and copper deficiencies.

Optimum rate of phosphorus application

Phosphorus requirements for sweet persimmon are very low. A 20 t crop removes about 5 kg/ha of phosphorus annually. This indicates that phosphorus uptake by the plant is slow, probably less than half that for nitrogen and potassium. Phosphorus quickly reverts to insoluble forms, particularly in acid soils. As a guide only, and allowing for leaching losses and fixation, about 15 kg/ha of elemental phosphorus should be applied.

Over-fertilising with phosphorus is very common in Australia, especially when mixed fertilisers are used. We recommend using mixed fertilisers with a low percentage of phosphorus.

Optimum leaf phosphorus concentrations

The optimum leaf phosphorus concentrations are set very narrowly between 0.10% and 0.18% one month before harvest.

Potassium (K)

Function

Potassium plays an important role in photosynthesis and carbohydrate production, in enzyme action and in disease resistance mechanisms within the plant. It also plays an important part in the regulation of water within the plant cell and water loss by transpiration.

Potassium is the most important cation in plant cells because of its physiological and biochemical functions. It is associated with the clay minerals in soils, which means that most clay soils have high potassium content, while sandy soils have low potassium content.

Symptoms

Deficiency symptoms first appear on recently matured leaves. Marginal leaf scorch on the older leaves is preceded by a yellowing between the veins (interveinal chlorosis). Deficiencies are more likely in sandy soils and in heavily cropped orchards.

Fruit yield

Potassium has a major effect on fruit yield. It may also affect fruit set. Yield and average fruit weight increase rapidly up to about 100 kg/ha of potassium per year and thereafter much more slowly (Figures 90 and 91). At greater than 120 kg/ha of potassium per year there is little additional response.

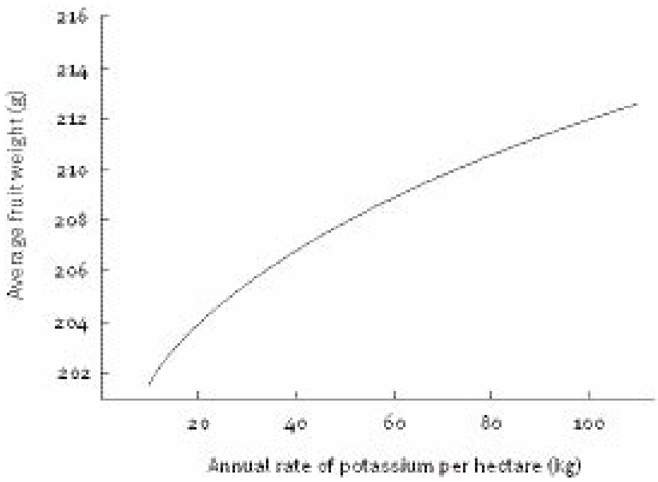


Figure 90 Effects of soil-applied potassium on fruit weight

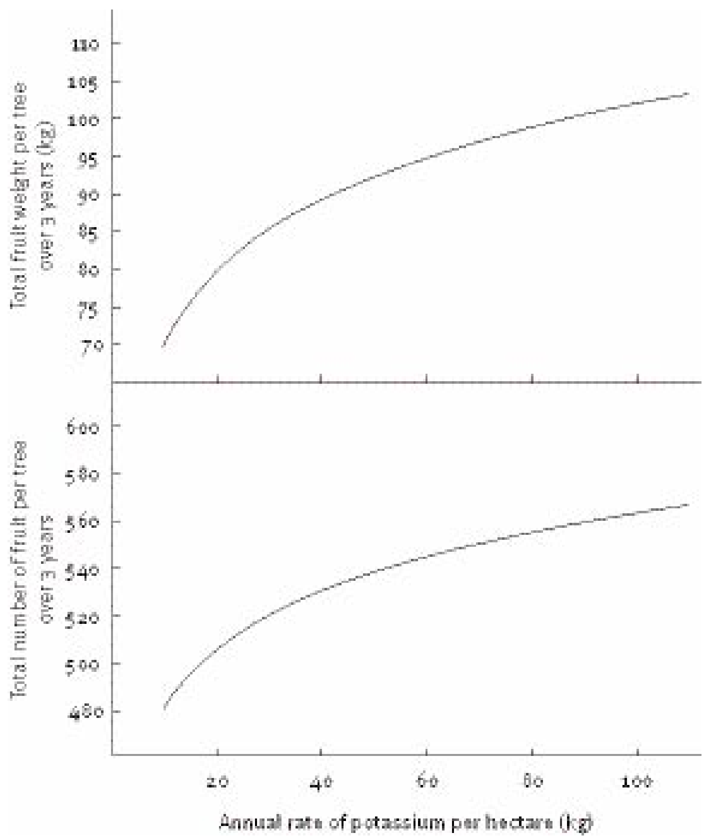


Figure 91 Effects of soil-applied potassium on total yield per tree over three years

Fruit quality

The effects of potassium on fruit quality are variable, with increases in sugar concentrations and fruit firmness seen only in some seasons (Figure 92).

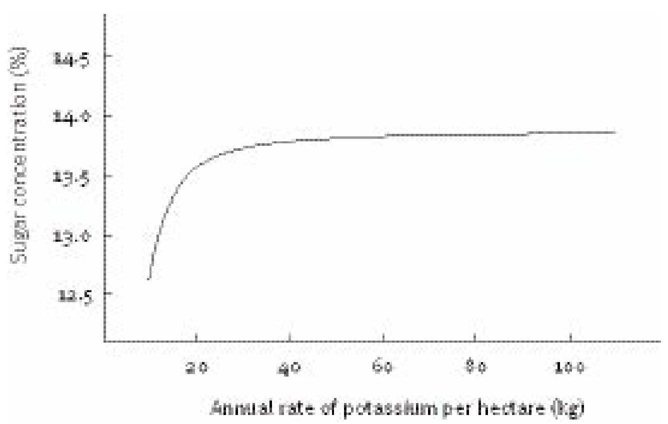


Figure 92 Effect of soil-applied potassium on sugar concentrations at Nambour, Queensland

Storage life

While higher rates of potassium may produce larger fruit and higher yields, fruit quality, and in particular storage life, may be adversely affected because of displaced calcium uptake particularly on low calcareous soil types (Figure 93). Many studies with apples have shown that the internal disorder bitter pit and short storage life are related to low calcium and high potassium concentrations in the fruit. The leaf calcium: potassium and leaf calcium:nitrogen ratios need to be greater than 1.5:1 one month before harvest (Figure 94).

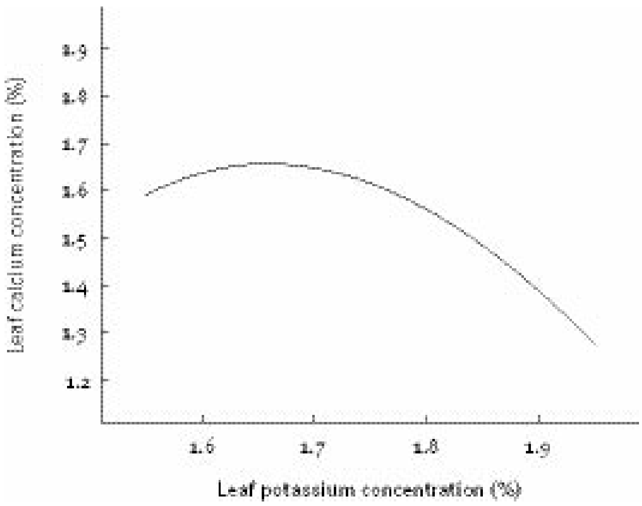


Figure 93 Relationship trend between leaf potassium and calcium concentration one month before harvest

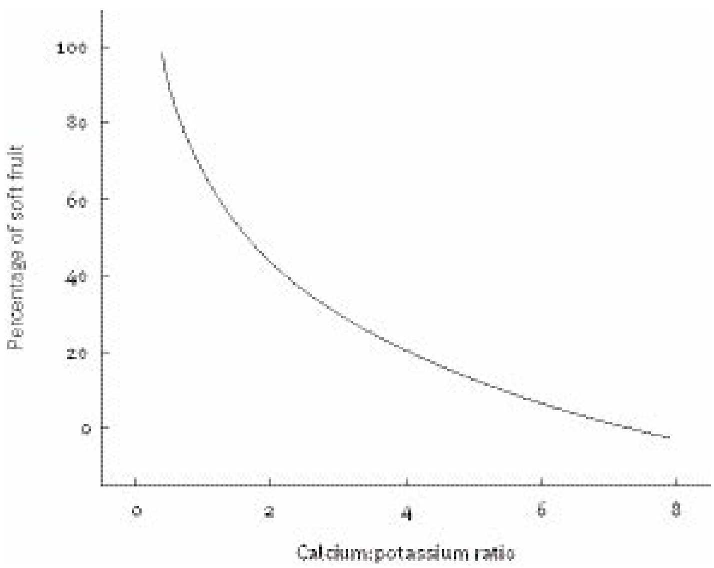


Figure 94 Relationship between fruit softening two weeks after storage at 21°C and leaf calcium:potassium ratio

Optimum rate of potassium application

The optimum application appears to be about 100 to 120 kg/ha of potassium. While higher rates than this can give slightly larger fruit and yields, fruit quality and in particularly storage life may be adversely affected, particularly on low calcareous soil types.

Excessive rates of soil-applied potassium can also lead to nutrient imbalances of calcium and magnesium and indirectly contribute to soil acidity. Cations such as potassium are generally not readily leached because they are strongly adsorbed onto the negatively charged clay minerals. Where high rates are applied and these sites are saturated, potassium will leach and will also exchange for calcium and magnesium. Potassium accumulates in the subsoil, emphasising the need for regular subsoil sampling and leaf analysis.

Optimum leaf potassium range

The optimum leaf potassium concentration one month before harvest is 1.5% to 2.0% to achieve maximum productivity and fruit quality. The leaf calcium:potassium ratio should be greater than 1.5:1.

Calcium (Ca)

Function

Calcium is required for cell elongation and division, and for cell walls. It is necessary for the proper functioning of growing points, particularly root tips, and it has an important role in nitrogen metabolism. Calcium also has a role in fruit ripening and quality, disease resistance and post-harvest life.

Symptoms

Deficiency symptoms appear first in the new growth, which is often deformed and yellow, and in severe cases shows tip burn.

Calcium is the dominant cation (positively charged ion) in the soil, accounting for 60% to 80% of the total cation exchange capacity. Soil structure is enhanced by calcium, making it more favourable for root growth and development. Excessive potassium will lower calcium uptake from the soil.

Fruit quality

Poor fruit firmness and storage life are major problems of sweet persimmons grown in subtropical Australia. These problems may be due to the inadequate mineral nutrition of developing fruitlets, which in turn may result from poor uptake of nutrients or competition between fruit and leaves for nutrients. Maintaining soil pH between 6.5 and 7.0 and soil calcium at greater than 8.0 meq/100 g can increase fruit firmness by 20% and storage life by two to three weeks. Shelf life is highly correlated with leaf calcium (Figure 95).

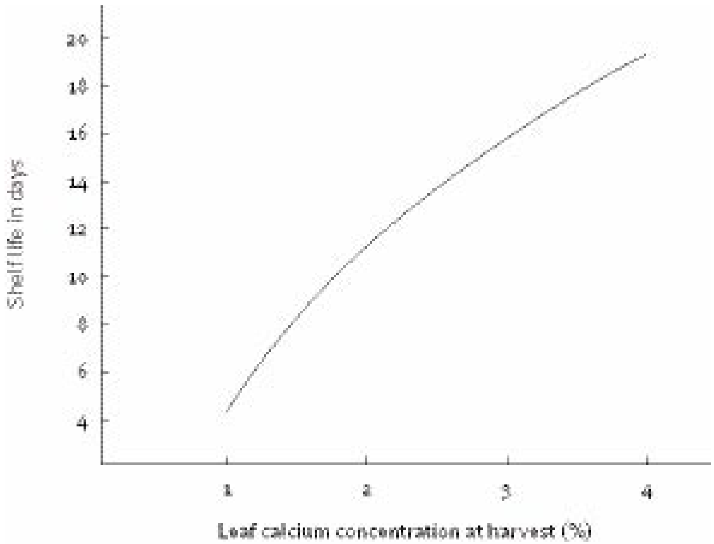


Figure 95 Relationship between leaf calcium concentration and shelf life at ambient temperature for selected orchards

Potassium and nitrogen fertilisers and calcium uptake

High rates of potassium applied during bud break and fruit set may reduce the uptake of soil calcium during its main absorption period, particularly in low calcareous soil types. Leaf calcium is often negatively correlated with leaf potassium (Figure 93). Excessive applications of nitrogen have also been shown to reduce fruit calcium concentrations, and consequently fruit firmness and storage life.

Effects of boron on leaf calcium concentrations

Boron is often associated with calcium uptake. Leaf calcium concentrations increase with leaf boron concentrations, with leaf calcium concentrations levelling off at about 100 mg/kg boron (Figure 96).

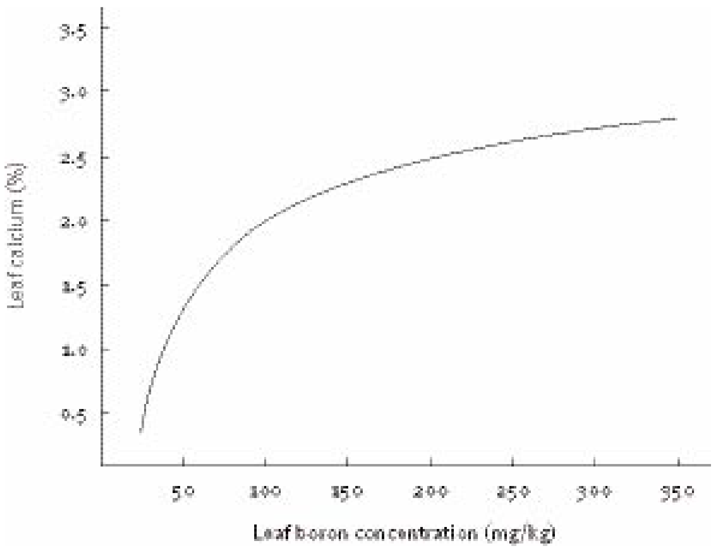


Figure 96 Relationship between leaf boron concentration and leaf calcium concentration one month before harvest for selected persimmon orchards

HINT

Soil moisture stress and soil waterlogging and/or high humidity are major factors that reduce calcium uptake.

Effects of environment on calcium uptake

Low soil and air temperatures during fruit set adversely affect calcium uptake (Figure 97). There is a strong correlation between mean minimum air temperature preceding fruit set and leaf calcium concentration at fruit set. Minimum air temperatures of 10°C and below appear to be the critical temperatures when calcium uptake is markedly affected. Soil moisture stress and soil waterlogging and/or high humidity are major factors that reduce calcium uptake.

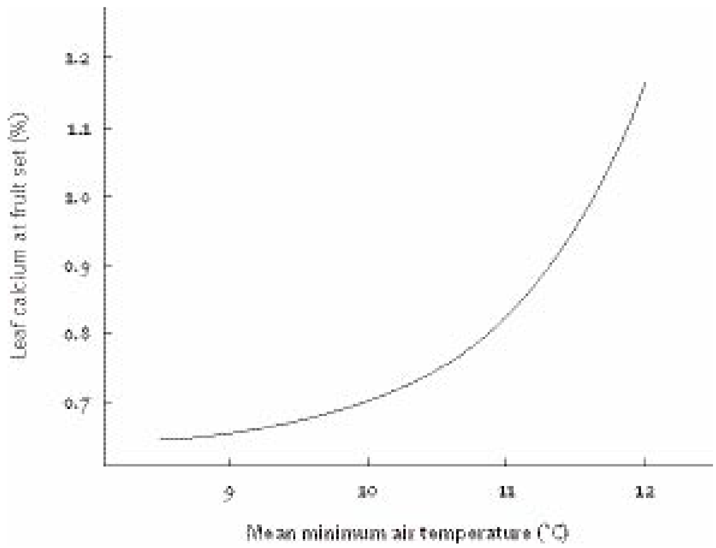


Figure 97 Relationship between leaf calcium at fruit set and mean minimum temperature in the six weeks from bud break to fruit set

Irrigation system

Poor calcium uptake has been linked to micro-tube irrigation systems where the soil profile has been insufficiently wetted during the critical uptake period from flowering to three months after fruit set. Growers should check their soil profile to make sure it is being wetted thoroughly.

Foliar application of calcium

HINT

Foliar applications of calcium and boron have only a small effect on improving fruit quality and storage life. These products are very expensive and reliable field data reporting on their efficacy is often not available.

Foliar applications of calcium and boron have been shown to slightly improve firmness and storage life. Responses are often variable and inconsistent.

Up to 10 applications may be necessary to have any effect. The timing of foliar applications of calcium may be important. Japanese studies have shown that most calcium is absorbed during the first two months after fruit set, and that very little calcium is taken up at later stages of fruit development. As insurance, it may be beneficial to apply foliar applications of calcium during seasons of low soil and air temperatures for adequate levels at fruit set. However, the key to increasing calcium in the plant is to have a correct soil cation balance, and to have adequate calcium present in the soil.

Establishing critical leaf calcium concentrations at fruit set and harvest

Higher leaf calcium concentrations at fruit set are moderately correlated with higher leaf calcium concentrations in January but not at later dates (Figure 98). The increase in leaf calcium concentrations between fruit set and January is about double that between January and harvest. It is essential to achieve maximum calcium uptake during the major absorption period during fruit set and for two months after fruit set.

NOTE

If calcium uptake is reduced during fruit set, then final calcium concentrations before harvest may be low.

For maximum storage life, a leaf calcium concentration of greater than 2.5% one month before harvest is necessary. To achieve this, leaf calcium concentration at fruit set should be greater than 0.8% and, by January, greater than 2.0%.

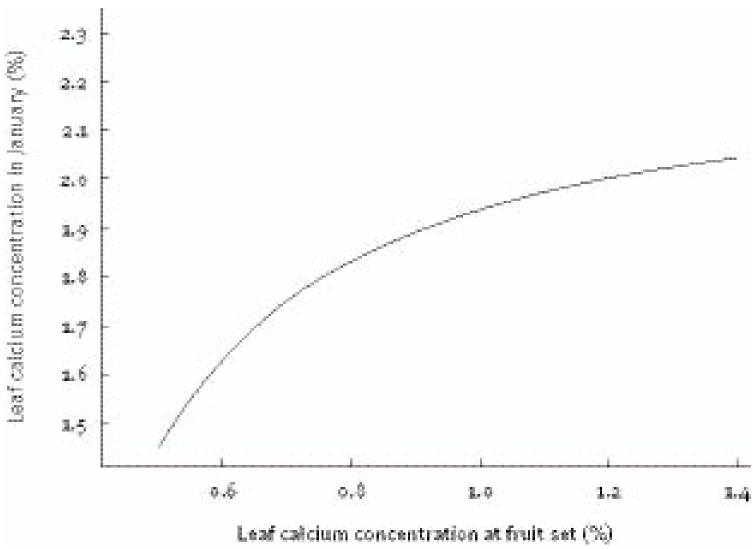


Figure 98 Relationship between leaf calcium concentration at fruit set and in January, at the end of Stage 1 fruit growth

Interactions

The uptake of calcium by the sweet persimmon tree is complex, with many interactions between the tree, soil and weather factors (Figure 99). The dominant factor is the weather, especially very wet or very dry conditions. In addition to modifying the soil levels of calcium, potassium and boron it may also be necessary to alter other practices. It may be necessary to:

- increase soil temperature during fruit set by plastic mulching
- reduce crop loads through thinning
- ensure that fruit are fully pollinated by planting polliniser trees and using beehives in the orchard
- control growth through summer pruning.

Avoid excessive hard winter pruning as this will cause excessive growth of shoots, which will compete for calcium during early fruit development.

In the future, clonal propagation of selected rootstocks that have higher uptake of calcium may be possible.

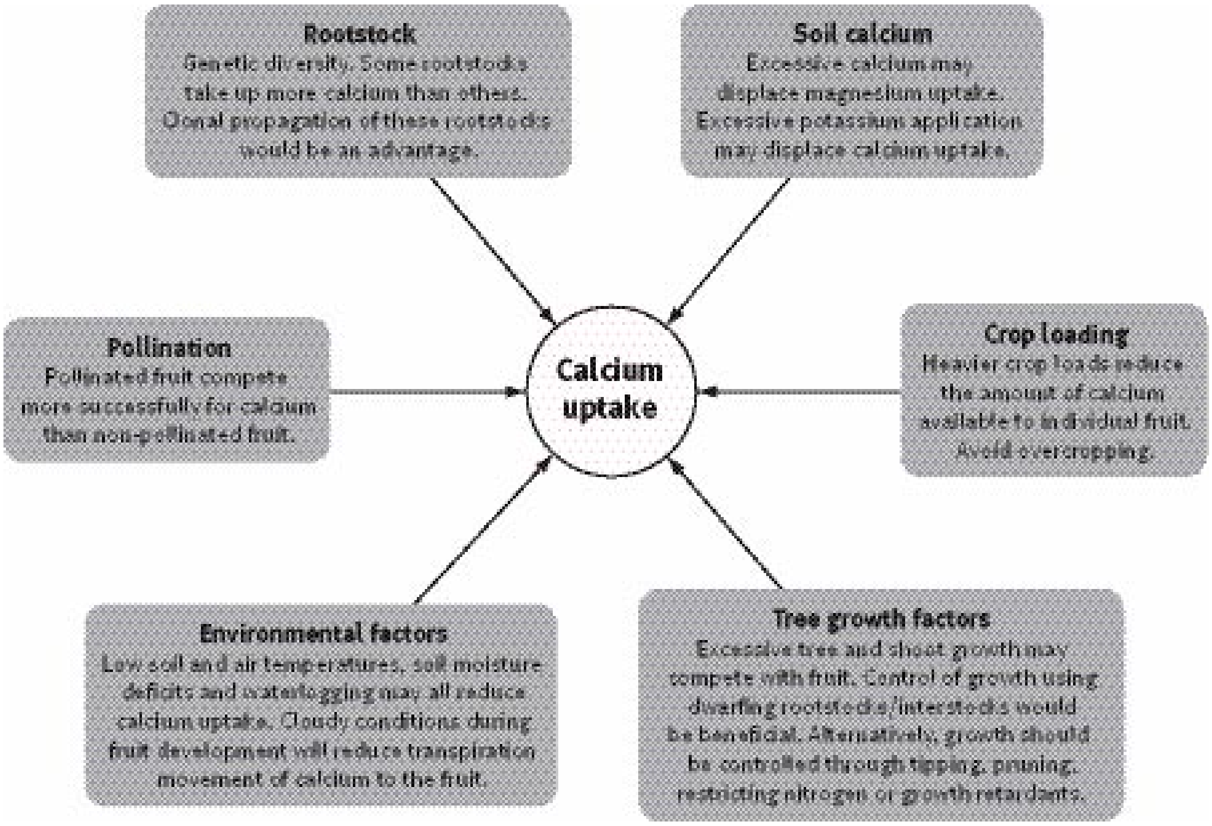


Figure 99 Interrelationships between soil, tree and weather factors that affect calcium uptake

Magnesium (Mg)

Function

Magnesium is a component of chlorophyll, the green pigment found in leaves. Magnesium also has a role in phosphorus transport.

Symptoms

Initial deficiency symptoms consist of yellowing between the veins of basal leaves on bearing shoots; the symptoms gradually appear on leaves higher up the shoot. In severe instances necrotic patches develop in the interveinal tissue.

Magnesium deficiency is common in areas of light sandy soils and high rainfall. High leaf nitrogen levels are associated with higher magnesium levels. Calcium and potassium compete with magnesium for uptake by the tree.

Nutrient interactions

Magnesium deficiencies usually occur on heavy cropping trees in late summer and early autumn, and are more pronounced during dry summers. Applying heavy rates of potassium and calcium fertilisers can induce magnesium deficiency. Leaf magnesium concentrations from January through to harvest are negatively correlated with leaf potassium concentrations (Figure 100).

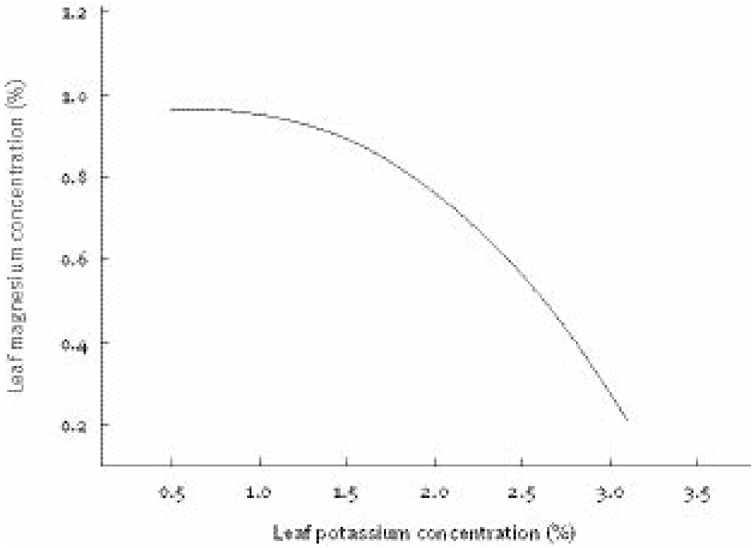


Figure 100 Relationship between leaf potassium and leaf magnesium concentrations one month before harvest

Optimum rate of magnesium application

The optimum rate of magnesium to apply will vary with soil type, leaching losses and many other factors. An average rate of magnesium to apply is 70 kg/ha per year of elemental magnesium. This rate will need to be adjusted according to leaf and soil analyses.

Optimum soil and leaf magnesium concentrations

Excessively high soil calcium levels due to liming can displace magnesium on the soil colloids and reduce uptake. Ideally, the soil calcium:magnesium ratio should be maintained between 3.5:1 and 5.0:1. After allowing for the interaction with potassium, the optimum leaf magnesium concentration before harvest appears to be between 0.6% and 0.9%. Leaf concentrations lower than 0.15% are deficient. The variety Jiro is more susceptible to magnesium deficiency than Fuyu.

Trace elements

Manganese (Mn)

Function

Manganese, in association with iron, copper and zinc, is important in the growth processes. Chlorophyll production, and carbohydrate and nitrogen metabolism of the plant depend on manganese. High manganese levels in plants may induce an iron deficiency.

Symptoms of deficiency

Manganese deficiency is characterised by the appearance of black necrotic spots on the basal leaves of new shoots at the beginning of early summer. Deficiency symptoms also include interveinal yellowing of young leaves. The major veins retain their dark green colour. Leaf manganese concentrations lower than 30 mg/kg are considered deficient. Deficiencies are rarely seen in Australia.

Deficiency control

A foliar application of manganese sulphate will control a deficiency. Regular use of some protectant fungicides also provides this micronutrient. Mancozeb fungicide applications can lead to an artificially high leaf analysis reading because the elemental manganese that is applied binds to the leaf.

Symptoms of toxicity (green blotch disorder)

Localised sections of the fruit fail to colour properly and retain a green blotchy appearance. Green blotch is highly correlated with high manganese and low calcium concentrations in the leaf and fruit and may be caused by excessive absorption of manganese. Some varieties, such as Matsumotowase Fuyu, are more susceptible than others.

Toxicity control

Manganese toxicity has been corrected by liming to increase soil pH and decrease available soil manganese. Foliar applications of calcium carbonate during early fruit development also reduced the severity of the problem.

Optimum leaf and soil manganese concentrations

Leaf manganese concentrations are reduced as leaf calcium concentrations increase (Figure 101). In Australia, the DTPA extraction method is used to measure manganese levels in the soil but this test has proven unreliable. Japanese research has shown that the water soluble extraction method is more reliable, with soil manganese of about 7 mg/kg producing toxicity symptoms. The water soluble test is not commonly used in Australia. A 2.5 mg/kg manganese level is the average for normal orchards.

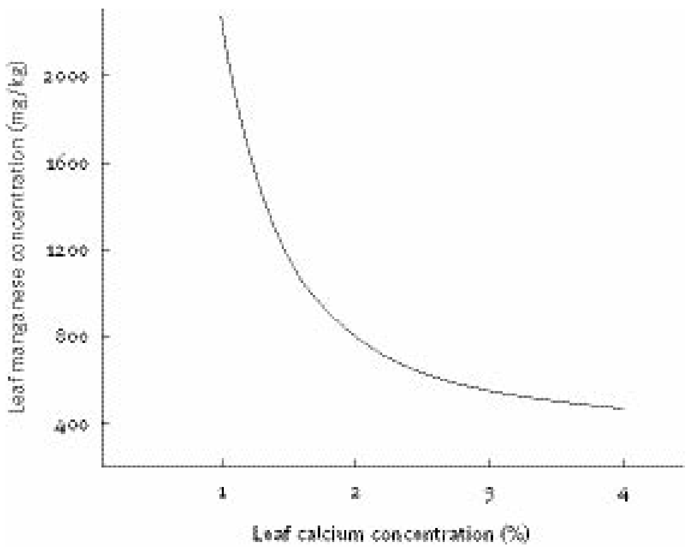


Figure 101 Relationship between leaf calcium concentration and leaf manganese concentration one month before harvest for selected persimmon orchards

Zinc (Zn)

Function

Zinc is involved in nitrogen metabolism, hormone synthesis and chlorophyll formation.

Symptoms

Symptoms appear in young leaves. Deficiencies can restrict leaf size or stem length or both—this is described as little leaf or rosetting. A distinct interveinal yellowing of the leaf is commonly seen. Heavy root-knot nematode infestation can induce similar symptoms.

Other nutrient interactions

Excess liming can contribute to zinc deficiency.

Copper (Cu)

Function

Copper is important in respiration and chlorophyll formation.

Symptoms

Deficiency can cause dieback of young growth and mottling of young leaves.

Other nutrient interactions

High levels of nitrogen and phosphorus produce a copper deficiency. Excess soil copper may induce an iron deficiency. Leached sandy soils receiving high nitrogen rates may show a copper deficiency.

Routine copper sprays for various bacterial and fungus diseases normally control any deficiency.

Boron (B)

Function

Boron is involved in the uptake and efficient use of calcium by the plant. It is important for new growing tissue in root tips and shoots and cell wall development. Most plants do not show boron deficiency until the problem becomes severe.

WARNING

Plants vary in their requirements for boron and the margin between deficiency and toxicity is narrow compared with other trace elements. Use very carefully.

Symptoms

In sweet persimmons, a deficiency can cause dieback of terminal twigs, curled leaf edges and dead buds. In severe cases bark will split and pit while fruit may be bumpy, irregularly shaped and cracked.

Other nutrient interactions

The uptake of boron is often associated with the uptake of calcium.

Iron (Fe)

Function

Iron is essential for chlorophyll formation, although it is not a constituent of chlorophyll. The amount of chlorophyll is apparently related to the readily soluble iron content in the plant. This element is the most immobile of all elements in the plant.

Symptoms

The main deficiency symptom is yellowing of leaves, the youngest being the first affected. Veins remain green. Deficiency is induced by:

- high pH (above 7.0)
- excessive soil moisture
- high concentrations of zinc and copper in acid soil
- low or high soil temperatures
- nematodes
- poor drainage
- very high phosphorus levels.

Iron chelate applied to the soil and soluble ferrous sulphate applied to leaves will control a deficiency. It is best to avoid growing trees in soils that are very alkaline or that contain lime.

A program for nutrition management

A complete soil analysis six months before planting will enable all nutrients to be adjusted to their appropriate levels throughout the intended root zone. This is particularly important for relatively insoluble fertilisers such as horticultural lime and dolomite (which supply calcium), gypsum, superphosphate (which supplies phosphorous), copper and zinc. These fertilisers are best applied to the soil surface and then worked into the entire root zone. It is difficult to do this after the trees have been planted.

Soil analysis

Buy a soil analysis kit from your farm supply store and follow the instructions. A soil test reveals the nutrient content of the soil at the time of sampling and the amount of nutrients that may become available during the life of the crop. It measures the level of:

- major nutrients—nitrate, sulphur, phosphorus, potassium, calcium and magnesium, and cation exchange capacity
- micronutrients—copper, zinc, manganese, iron and boron, soil acidity, pH and exchangeable aluminium
- soil salinity or sodicity—electrical conductivity, chloride and sodium
- organic matter content—organic carbon.

A garden spade or auger, a clean bucket and clean plastic sample bags are required.

Do not sample areas that are not representative of the orchard, such as fence lines, ditches, paths, fertiliser and manure patches or old vegetable gardens.

When to sample

Soil samples should be taken at the same time as the first leaf sample (at fruit set). Taking the soil sample at this time will allow for a better interpretation of leaf nutrient analyses and also allow time to apply fertiliser for corrective purposes before the end of the season. One soil sample per season should be sufficient.

Taking a sample

Avoid sampling residual fertiliser because this may give a false reading. If lime, dolomite, gypsum or other fertilisers have been applied to the sampled area, gently scrape away a thin layer of soil. Dig a hole, then take a thin slice down the side of the hole or alternatively drill the auger to the desired depth. See Figure 102.

(a) Select a sampling site under the tree canopy and in the sprinkler's wet area

(b) Take the sample at least 300 mm from the tree butt

(c) Avoid sampling applied fertiliser. Scrape a thin layer of soil away and sample beneath any fertiliser

(d) Sample at least 300 mm deep or take two samples, one at 0–150 mm and one at 150–300 mm. Place samples in separate, well-labelled containers

Figure 102 Taking a soil sample

Sample depth

Sampling to a consistent depth is important. This should be approximately the depth of the main root zone. Soils should be sampled to at least 300 mm depth or alternatively two samples could be taken, one at 0 to 150 mm and another at 150 to 300 mm.

Sampling the orchard

Divide the orchard into reasonably uniform areas. Do not mix soil types that are obviously different. Sample about 15 different sites from each uniform area. Select sampling sites that are under the tree canopy, within the wetted area of the sprinkler and no closer than 300 mm to the tree butt. Put the soil from the 15 different sites into a plastic bucket. If taking two soil depths, use two marked buckets, one for each depth.

Preparing the soil sample

A representative sub-sample must be taken from the bulk sample. Thoroughly mix the soil in the bucket and then remove about a cup of the mix. Do this by taking many pinches from the bucket, stopping occasionally to mix the remaining soil. Spread the cup of soil onto a newspaper or piece of plastic and let the soil air-dry for several hours in the shade.

This air-drying helps to prevent any chemical changes taking place while your soil is in transit. Put the air-dried soil into the sample bag provided with your test kit. Send the sample to the laboratory as soon as possible. It should be posted early in the week, so that it arrives at the laboratory before the weekend. Do not send on Fridays. If you must store the sample before posting, keep it in the refrigerator.

Labelling and mailing

Tie the sample bag securely and print your name, address and telephone number and the sample identification either on the outside of the bag or on a label tied to the neck of the bag.

Place the sample in a large Australia Post bonded bag, complete the information sheet and post the bag to the soil laboratory. A full test is recommended for sweet persimmon orchards. This includes soil pH, electrical conductivity, phosphorus and exchangeable cations, which include calcium, magnesium, potassium, sodium and aluminium.

You can analyse your own results or ask an agronomist or nutrition consultant to interpret them. They will recommend appropriate fertilisers and rates to bring nutrient levels within the desired ranges.

Optimum soil nutrient levels are shown in Table 23.

Table 23 Soil nutrient standards for sweet persimmon

Nutrient	Standards
pH (1:5 water)	6.5–7.0
pH (1:5 CaCl2)	5.5–6.0
Organic carbon (Walkley–Black)	greater than 2.0%
Nitrate nitrogen (1:5 aqueous extract)	greater than 10 mg/kg
Phosphorus (Colwell)	20–120 mg/kg
Potassium (exchangeable)	greater than 0.5 meq/100 g
Calcium (exchangeable)	greater than 8.0 meq/100 g
Magnesium (exchangeable)	greater than 1.6 meq/100 g
Sodium (exchangeable)	less than 1.0 meq/100 g
Chloride (1:5 aqueous)	less than 50 mg/kg
Conductivity (1:5 aqueous extract)	less than 1.0 dS/m
Copper (DPTA)	0.3–10 mg/kg
Zinc (DPTA)	2–15 mg/kg
Manganese (DPTA)	4–60 mg/kg
Manganese (water soluble)[1]	less than 2.5 mg/kg greater than 7 mg/kg, toxic
Iron (DPTA)	greater than 2 mg/kg
Boron (hot calcium chloride)	0.5–1 mg/kg
Calcium: magnesium ratio	3–5:1
Total cation exchange capacity	greater than 7
Cation balance (%)	calcium 65–80; magnesium 10–15; potassium 1–5; sodium less than 5

[1]More reliable test but not commonly used by Australian laboratories.

Leaf analysis

Leaf analysis provides a snapshot of the immediate nutrient status of the orchard, but cannot predict future nutrient deficiencies. Leaf analysis must be used in conjunction with soil tests to plan fertiliser strategies.

Leaves are analysed for total nitrogen, sulphur, phosphorus, potassium, calcium, magnesium, sodium, chloride, copper, zinc, manganese, iron, boron and aluminium. As a diagnostic tool, leaf analysis shows the nutrient concentrations at the time of sampling and indicates whether the supply of nutrients is adequate.

Leaf sampling must meet precise specifications regarding:

- timing
- position and type of leaf sampled
- representativeness of the sample.

When to sample

Leaf and soil samples should be taken twice a season:

- at fruit set (usually late October)
- one month before harvest (early March in south-east Queensland, early April in southern states).

Taking samples at both these times will show whether trees have optimum levels of nutrition and will allow any deficiencies to be corrected during the current season's growth.

Equipment

A sharp penknife, a clean paper bag (plastic bags are unsuitable) and clean hands are required for sampling.

Avoid taking samples of plants along roadways, headlands, old fence lines or where old vegetable gardens might have existed. Do not take samples during extreme weather conditions, such as floods, drought, extreme cold and heat waves, or immediately after spraying fungicides such as mancozeb or pesticides.

Taking a sample

Freestanding trees. Sample four leaves from each of 20–25 trees.

Hedgerows (palmette, V-trellis). Sample two leaves per tree, one from each side of 50 trees.

Take the first fully mature leaves, usually the fifth, sixth or seventh leaf back from the growing point. Sample only non-fruiting shoots as fruiting can affect leaf nutrient concentrations (Figure 103).

If there are variations in soil type, tree age or tree variety within the orchard, take separate samples for each block.

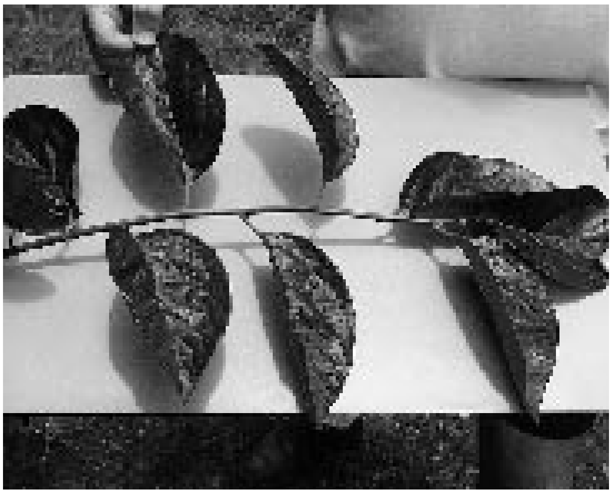
Preparing the leaf sample

Ensure that plant samples are sun-dried or air-dried before packing them to prevent mould developing. Protect the samples from contamination by dust and fertilisers and keep them cool by storing them in a cold box.

Labelling and mailing

Close the bag securely, carefully record the bag number and provide all the field information required. Place the bag in the pre-addressed express courier post pack, or an overnight post pack, and dispatch it as soon as possible, so that the plant material reaches the laboratory before the weekend. Do not send on Fridays.

(a) Select a shoot from each side of the tree



(b) Sample the first fully mature leaf (usually the 5th, 6th or 7th leaf) from the growing tip

Figure 103 Taking leaf analysis samples

Table 24 Australian leaf nutrient standards for mature (more than five years old) sweet persimmon trees

Nutrient	Standards at fruit set	Standards one month before harvest*
Nitrogen (%)	2.4–2.9, less than 2.0 deficient greater than 3.0 excessive	1.8–2.2, greater than 2.5 reduces fruit quality
Phosphorus (%)	0.16–0.3	0.10–0.18
Potassium (%)	2.0–3.0	1.6–2.2
Calcium (%)	0.8–1.6	2.5–3.5
Calcium:nitrogen ratio	–	greater than 1.5
Calcium:potassium ratio	–	greater than 1.5
Magnesium (%)	0.25–0.4	0.6–1.0, less than 0.13 deficient
Chloride (%)	less than 0.3	less than 0.4, greater than 0.8 reduces yield
Copper (mg/kg)	3–14	4–20
Iron (mg/kg)	20–100	120–250
Boron (mg/kg)	30–70	80–120
Zinc (mg/kg)	16–30	14–80
Manganese (mg/kg)	less than 500	less than 500

*Leaf nitrogen and potassium concentrations will be 0.2% to 0.5% higher for younger trees before they start to crop heavily.

Table 25 Guide to interpreting soil analysis results

Element	Desired levels	Interpretation
pH (1:5 water)	6.5–7.0	6.5 about ideal. If below 6.5, apply dolomite if calcium:magnesium ratio (in this table) is close to 3–5:1. Otherwise use lime.
pH (1:5 $CaCl_2$)	5.5–6.0	6.0 about ideal. If below 6.0, apply dolomite if calcium:magnesium ratio (in this table) is close to 3–5:1. Otherwise use lime.
Organic carbon—%C (Walkley-Black)	2.0–5.0	If less than 2, use green manure crops, mulches and organic manures.
Nitrate nitrogen—mg/kg (1:5 aqueous extract)	> 10	If less than 10, apply at recommended rates. Apply about 30% to 50% more if losses are expected. If 20 to 40, apply at crop replacement rates. If more than 60, no application is necessary.
Phosphorus—mg/kg P (Colwell)	20–120	If less than 60, apply at rate of 30 kg/ha phosphorus, more if losses are expected. If 60 to 100, apply at replacement rates. If more than 100, no application is necessary.
Potassium—meq/100 g K (exchangeable)	> 0.5	If less than 0.5, apply at recommended rates. Allow an extra 20% to 30% if losses are expected. If 0.5 to 1, apply at replacement rates. If more than 1, no application is necessary.
Calcium—meq/100 g Ca (exchangeable)	> 8	If less than 8, apply lime, dolomite or gypsum depending on pH and calcium:magnesium ratio. If more than 8 and pH is more than 6.5 (1:5 water), no application is necessary.
Magnesium—meq/100 g Mg (exchangeable)	> 1.6	If less than 1.6, with pH more than 6.5 and calcium:magnesium ratio of 4:1 or more, no application is necessary. If more than 1.6, with pH more than 6.5 and calcium:magnesium ratio of 4:1 or more, apply magnesium oxide at 100–200 kg/ha.
Sodium—meq/100 g Na (exchangeable)	< 1	If more than 1, check quality of irrigation water and height of water table.
Chloride—mg/kg Cl (1:5 aqueous extract)	< 50	If more than 50, check quality of irrigation water and height of water table, and use sulphate forms of potassium fertiliser.
Conductivity—dS/m (1:5 aqueous extract)	< 1	If more than 1, check quality of irrigation water, fertiliser rates and height of water table.
Copper—mg/kg Cu (DTPA)	0.3–10	Rarely out of adequate range.
Zinc—mg/kg Zn (DTPA)	2–15	If less than 2, check leaf analysis level to see if overall deficiency is confirmed. Follow recommendations.
Manganese—mg/kg Mn (DTPA)	4–60	Rarely out of adequate range. If more than 60, aim for a pH (1:5 water) of 6.5–7.0.
Iron—mg/kg Fe (DTPA)	> 2	Rarely out of adequate range.
Boron—mg/kg B (hot calcium chloride)	0.5–1	If less than 0.5, check leaf analysis level to see if overall deficiency is confirmed. Follow recommendations.
Calcium:magnesium ratio	3–5: 1	See pH, calcium and magnesium above.
Total cation exchange capacity	> 7	See pH, calcium, magnesium and potassium above.
Cation balance (%)	Calcium: 65–80; magnesium:10–15; potassium:1–5; sodium: < 5	See pH, calcium, magnesium and potassium above.

Table 26 Guide to interpreting leaf analysis results

Nutrient	Desired range at fruit set	Interpretation
Nitrogen (% N)	2.4–2.9	If below desired levels, may indicate insufficient fertiliser, poor application or root damage. Use soil analysis results to determine rates of application. If within or above desired range, use soil analysis results to determine rates of application.
Sulphur (% S)	0.2–0.4	Rarely out of range.
Phosphorus (% P)	0.16–0.3	If within desired range, no action necessary. If below or above desired range, use soil analysis results to determine rates of application.
Potassium (% K)	2.0–3.0	If below desired levels, may indicate insufficient fertiliser or competition for uptake with high levels of calcium and/or magnesium. Use soil analysis results for potassium, calcium and magnesium to determine rates of application. Remember that potassium levels fall as the crop load increases on the tree, so timing of sampling is important when interpreting analysis results. If within or above desired range, use soil analysis results to determine rates of application.
Calcium (% Ca)	0.8–1.6	If below desired range, may indicate low soil pH, insufficient calcium fertiliser or an imbalance with potassium and/or magnesium. Use soil analysis results for potassium, calcium, magnesium and pH to determine type of fertiliser and rates of application. If within or above desired range, no action necessary. Maintain at the top end of this scale if the incidence of woodiness or brown pulp disorders in the fruit is high.
Magnesium (% Mg)	0.25–0.4	If below desired range, may indicate low soil pH, insufficient magnesium fertiliser or an imbalance with potassium and/or calcium. Use soil analysis results for potassium, calcium, magnesium and pH to determine type of fertiliser and rates of application. If within or above desired range, no action necessary.
Zinc (ppm Zn)	16–30	If below desired range, may indicate high soil pH, excessive phosphorus or excessive nitrogen. If soil levels also low, apply zinc sulphate monohydrate to the soil under the trees at a rate of 2–3 g/m2. Alternatively, apply a foliar spray of zinc sulphate heptahydrate (1 kg) + hydrated lime (500 g) per 100 L water to the spring flush. If within or above desired range, no action necessary.
Copper (ppm Cu)	4–14	Rarely out of range if fungicide sprays are used.
Sodium (% Na)	< 0.15	If more than desired level, check quality of irrigation water and soil analysis results.
Chloride (% Cl)	< 0.3	If more than desired range, check quality of irrigation water and soil analysis results.
Iron (ppm Fe)	20–100	Rarely out of range except where heavy applications of lime or dolomite have been made.
Boron (ppm B)	30–70	If below desired range, apply 1–2 g of borax or 0.5–1 g of Solubor per square metre of soil surface beneath the trees. Boron can become toxic so check leaf levels two months later before any further applications are made. If within or above desired range, no action necessary.
Manganese (ppm Mn)	< 500	If below 50 ppm, apply a foliar spray of manganese sulphate at 100 g/100 L to the spring flush.

Interpretation of soil and leaf analysis results

The laboratory analysing your soil samples will interpret the results and recommend appropriate fertilisers and rates to bring the levels of all nutrients within the desired ranges. Tables 25 and 26 provide broad guidelines to interpreting leaf and soil analysis results.

Management of nutrients

Sweet persimmon production areas have different climatic (particularly rainfall) and soil conditions. These differences mean orchards must be assessed individually, from the time of establishment to bearing.

Irrigation and water management

The importance of good irrigation management

The sweet persimmon tree, although moderately drought tolerant, requires good water management to maximise yield and fruit quality.

Too little water causes:

- reduced yields of up to 30% compared to well watered trees, particularly in orchards with no pollinisers. This is due mainly to the reduced number and size of fruit
- increased fruit drop in early summer
- poor internal quality because of a reduced uptake of boron and calcium during flowering and early fruit development
- more rapid ripening of fruit.

Too much water causes:

- increased tree shoot growth and vigour
- potential death of the tree, although sweet persimmon does tolerate some waterlogging
- increased incidence and severity of rootrots and other fungal problems
- increased risk of nutrient imbalances. Levels of some available nutrients will become toxic under waterlogged conditions
- increased leaching of nutrients from the root zone, which wastes fertiliser and pollutes the groundwater.

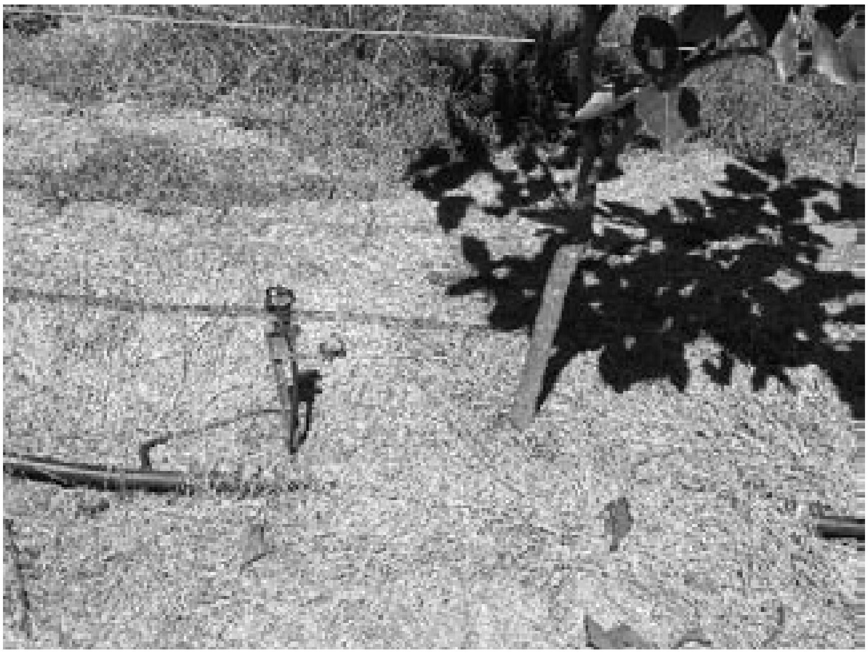


Figure 104 Young tree set up with a mini-sprinkler system

Factors affecting water demand and availability

Tree condition and size

Trees with sparse foliage use less water than trees with dense foliage and small trees use less water than large ones.

Stage in the growth cycle

Water need is high from flowering until fruit have reached full size. Critical periods are at flowering and fruit set, during early fruit growth and when fruit are approaching maturity. Note these important points:

- Severe water stress at flowering may result in a very small crop or no crop at all.
- Water stress during early fruit growth may affect fruit size and quality, as well as yield. A continuous flow of water through the plant is necessary to supply the calcium necessary to develop quality fruit.
- Water stress increases fruit drop within two to six weeks after fruit set. Poorly pollinated fruit will drop first.

Climate and weather conditions

The amount of water required by the tree is directly related to the net evaporation rate. Evaporation is highest when humidity is low and conditions are hot and windy. Trees adjust to these conditions by closing their leaf stomata (water pores) to reduce moisture loss. However, when this happens, photosynthesis is reduced and potential productivity is affected.

Root distribution

About 80% of the sweet persimmon feeder root system is found in the top 450 mm of soil; only a small percentage is at depths greater than 500 mm. Because the greatest water demand is at relatively shallow depths, the upper root zone must be kept moist at all times through irrigation and mulching.

Soil features

Surface condition. An open loose soil surface allows better water penetration from rainfall and irrigation. An open loose soil surface is best achieved through mulching.

Texture. Soil texture affects water storage capacity. Well-structured clay soils will store more water than coarse sands, so sandy soils will need to be irrigated more frequently than clays. However, there is also the risk of over-irrigating sandy soils and wasting water and nutrients.

Soil texture also affects water infiltration. Coarser textured sands will allow rain or irrigation water to infiltrate at a faster rate than finer textured clays. On heavy clay soils more water will generally run off during heavy rain. The infiltration rates of well-structured volcanic red krasnozem soils (clay loams) are similar to those of sandy loams. Infiltration rates (usually measured in mm/hour) need to be taken into account when designing irrigation systems.

Depth. The greater the depth of well-drained soil, the greater is the water reservoir that the tree can draw from.

Organic matter. Soils with higher organic matter levels can store more water.

Mounds

Mounds are sometimes constructed where the depth of well-drained soil is marginally less than what is required for good soil drainage. However, mounds tend to dry out faster than flat ground and may require up to 20% extra water. Carefully monitor soil moisture in these situations.

Figure 105 Mounds can improve drainage. However they should not be built too high

Water quality

Sweet persimmon trees are sensitive to the quality of irrigation water. Water salinity or conductivity should preferably be less than 0.65 dS/m and chloride content less than 80 mg/L. Test all new irrigation sources before use and test all existing sources regularly.

In the Sunraysia and Riverland areas, where water quality may be marginal, growers should choose rootstocks with some salinity tolerance. Also, in these situations, heavier irrigations are required from time to time to flush accumulated salts out of the root zone.

Variability in the orchard

Soil texture, soil depth and other factors affecting water availability can vary significantly in an orchard and this should be taken into account when designing and operating an irrigation system. Trees on different soil types should be irrigated separately.

We recommend that growers develop a soil map of their orchard block.

This is a general map of the property that shows the main features and block boundaries, as well as soil texture and depth from several inspection holes on a grid pattern across the block.

For a small property, the holes can be dug by hand with a soil auger or posthole digger. For a larger property, hire a contractor with a motorised truck-mounted auger. Contractors providing this service are generally listed in the local Yellow Pages directory under Soil testing and investigation.

Mulch

Mulching is a significant help in managing water, rootrot, weeds and nutrient uptake. Mulching helps reduce evaporation from the soil and reduces fluctuations in soil temperature. As a result, soil microflora increase in number, organic matter builds up and a more open soil structure develops.

Higher organic matter levels and a more open soil structure allow water to penetrate more easily. The soil can also store more moisture, which is particularly important during the critical periods of flowering, fruit set and early fruit growth. Substantial savings in irrigation water can be achieved by mulching.

Compaction

Soil compaction reduces water infiltration and water storage and inhibits root penetration. Although machinery traffic will inevitably cause some inter-row compaction, the problem can be minimised in the following ways:

- Maintain an inter-row plant cover. Cover plants help reduce surface soil erosion and their roots help keep the soil structure open. Healthy cover plants require good canopy management so that sufficient light reaches the orchard floor.
- Avoid unnecessary use of machinery in the orchard. Monitor pests to avoid unnecessary spraying, use fertigation to minimise machinery application of fertilisers, and increase intervals between slashing.
- Avoid the use of machinery immediately after rain, as this often seals the soil surface.
- Limit the area subjected to compaction by using the same wheel track positions when travelling down the inter-row.
- Consider using a soil renovator about once a year. Several types are available, but they all open up the soil surface without significantly damaging root systems or the inter-row plant cover.

Figure 106 Maintain inter-row plant cover. This helps keep the soil structure open. Note mounds to improve drainage

Windbreaks

Windbreaks prevent excessive water loss from foliage under windy conditions. They are recommended in all orchards that are not netted. When installing irrigation, cater for the windbreak trees as well as the orchard trees. This helps them to grow faster and provide protection earlier.

A good irrigation system

The requirements for efficient irrigation are:

- a reliable supply of good quality water
- an irrigation system capable of evenly delivering the requirements of the tree
- an effective means of monitoring water requirements so the required amount of water can be applied at the right time.

This subsection covers the irrigation system while the next discusses monitoring systems.

When designing and building an effective irrigation system, there is no substitute for experience. We recommend that you use a qualified irrigation designer to prepare an irrigation design plan.

Under-tree mini-sprinklers provide the best option for keeping all of the roots hydrated (Figure 104). However, some growers use trickle systems quite successfully; on sandy loam soils, two trickle lines per row may be needed to fully wet the root zone (Figure 107).

A mature tree requires two mini-sprinklers, one on either side of the trunk. Make sure the irrigation design supplies enough water to the under-canopy area for the tree's requirements. Remember to allow extra capacity in the design to water windbreak trees and to provide additional water to the rows of sweet persimmon trees planted adjacent to the windbreak trees.

Some growers irrigate the total ground area (inter-row as well as under-canopy) so that mulch material can be grown between the rows. However, this practice requires significantly greater water volumes.

Emitters should be interchangeable so that the amount of water delivered can be varied. Colour coding of the emitters makes this easy. For example, if a tree is sick, it should be easy to remove a 120 L/hour emitter and replace it with an 80 L/hour emitter.

Good filtration is important to minimise blockages. Check sprinklers regularly to ensure they are operating correctly.

Figure 107 Trickle system commonly used in southern Australia. Note the double drip lines per row, which are needed to supply sufficient volumes when trees reach maturity

Potential pitfalls

There are several potential pitfalls to be aware of when using under-tree mini-sprinklers.

Operating pressure. Sprinklers only operate satisfactorily within a restricted pressure range. If the pressure is too low, water will be dumped at the end of the sprinkler's throw (donut effect); if the pressure is too high, misting will occur.

Pressure variation. Ensure that pressure does not vary by more than about 10% across the block. Large pressure variations lead to uneven watering, with more water delivered by the high-pressure sprinklers and less by the low-pressure sprinklers.

Where pressure variation exceeds 10%, sprinklers must be fitted with pressure compensators. A well-designed system using irrigation laterals that are appropriately tapered should not need pressure compensators, but they may be necessary for blocks with significant variations in slope and altitude.

Flushing valves. To avoid localised waterlogging, extend laterals beyond the tree rows and fit flushing valves. This ensures that water remaining in the lines after irrigation drains away rapidly and harmlessly.

Sprinkler distribution uniformity. If the sprinklers distribute water unevenly, some parts of the root zone will receive too much water and others too little. Where fertigation is used, this will also cause uneven fertiliser application.

Even application is particularly important for boron fertilisers, where uneven watering can lead to boron toxicity. Where poor quality water is used, uneven watering allows salt build-up in localised areas.

Sprinkler uniformity can be measured using the Distribution Uniformity (DU) test. In this test, a grid of cans (minimum 36 cans) is placed between sprinklers in the field and the volume of water in each can is measured. To calculate the DU:

$$DU\% = \frac{\text{Average volume per can of the lowest quarter of can volumes} \times 100}{\text{Average volume for all cans}}$$

A DU equal to or greater than 75% is very good, with values less than 67% being unacceptable.

Correct height of sprinkler. The optimum water distribution pattern is achieved when the sprinkler is positioned at the manufacturer's recommended height above the ground.

Worn sprinklers. Sprinklers have a limited life and should be checked for the following signs of wear:

- leaking from the base of the sprinkler when the washers have worn, causing pooling on the ground
- slow or uneven rotation
- loss of diameter of throw (worn sprinklers often have a reduced throw).

Blocked sprinklers. Sprinklers with low emitter rates have small apertures and are more easily blocked. Inadequate filtration, algae build-up, eggs laid by weevils or ants building nests can cause blockages. This generally occurs if the system has not been used for some time. Anti-ant sprinklers are available from some manufacturers. A good management practice is to take a quick run up each inter-row on a motorbike and check sprinkler operation at the start of the irrigation.

Animal interference. Large birds such as crows and cockatoos may physically remove sprinkler heads, and rodents or dogs may chew laterals. Seek local knowledge on sprinkler types and emitter rates that cope best with these problems.

New irrigation developments

Pulse irrigation. This system, developed in Israel, uses short pulses of irrigation several times a day to keep the shallow feeder root zone continuously moist. In theory, it enables the tree to maintain active water and nutrient uptake for longer periods of the day, potentially increasing productivity and fruit quality. It is becoming popular in areas with hot dry summers such as south-west Western Australia, the Riverland and Sunraysia.

Tips for managing with limited water

- Eliminate weed competition near trees, preferably by using a thick layer of mulch.
- Mulch trees, particularly during the drier winter and spring months (subtropical regions) in advance of peak water demand times and high temperatures.
- Choose sprinklers that wet the main root area only.
- Choose an irrigation system that minimises misting. This is usually achieved by using a high-output, low-pressure sprinkler.
- Mow the inter-row plant cover to keep it from becoming too rank and competing with the trees.
- Irrigate at night. Remember to check sprinkler operation.

Soil moisture monitoring systems

For effective irrigation, a monitoring or scheduling system is essential to help decide when to water and how much to apply. Monitoring greatly improves the chances that water will be applied at the right time and in the correct quantity to maximise yield and fruit quality.

A range of equipment and techniques is available for monitoring soil moisture and scheduling irrigation. The most common are soil-based systems such as tensiometers, soil moisture sensors and soil capacitance systems (e.g. EnviroSCAN). The other main technique is a climate-based system that uses estimates of evapotranspiration.

We recommend soil-based systems. A brief comparison of the main systems is shown in Table 27.

Table 27 Comparison of the main soil moisture monitoring systems

System	Advantages	Disadvantages
1. Tensiometers	• Relatively cheap • Easy to install • Easy to read • Continuous monitoring	• Labour intensive to collect and record data • Requires regular maintenance • Can be inaccurate in extremely wet or dry soil • Not accurate in very sandy soils • Indicates when to irrigate, but not necessarily how much to apply
2. Soil moisture sensors	• Relatively cheap • Easy to install • Moderately easy to read • Continuous monitoring possible	• Labour intensive to collect and record data • Requires a digital meter for taking sensor readings • Can be inaccurate in extremely wet or dry soil • Indicates when to irrigate, but not necessarily how much to apply • May only last up to 18 months because the gypsum breaks down
3. EnviroSCAN or C-Probe capacitance probes	• Automatic continuous monitoring • Highly accurate at all depths and for all soils • Enables rapid reading and recording of results • Indicates both when to water and how much to apply	• Expensive • Needs skill to interpret data—training and support recommended • Computer required • Not portable
4. Evaporation pans	• Inexpensive. No in-field measurement is needed because the system uses weather data to predict irrigation needs • Invaluable when planning the orchard to estimate annual requirements and peak demand needs	• Less accurate as system ignores soil variability and the performance of the irrigation system • Requires evaporation and rainfall data • Cannot accurately assess the effectiveness of rainfall received • Error can build up; actual soil moisture needs to be checked periodically

Because sweet persimmon trees draw water mostly from the top metre of soil, with the greatest demand from the top 500 mm, soil water monitoring devices must concentrate on this part of the soil profile.

Tensiometers

Tensiometers, provided they are well sited and maintained, are a relatively cheap and effective way of monitoring soil moisture. They are probably the most commonly used system.

A conventional tensiometer consists of four basic parts—a hollow tube filled with water and algaecide, a ceramic tip, a water reservoir and a vacuum gauge which reads water tension on a scale of 0 to 100 centibars (cb) or kilopascals (kPa) (Figure 108).

When the soil is saturated, the tensiometer is full and the vacuum gauge displays 0 kPa. As the soil dries over several days, water moves from inside the tensiometer, through the porous ceramic tip and into the soil. The gauge reading steadily increases to a maximum of about 90 kPa. When the soil is re-wet after rain or irrigation, water moves from the soil back into the tensiometer and the gauge reading falls.

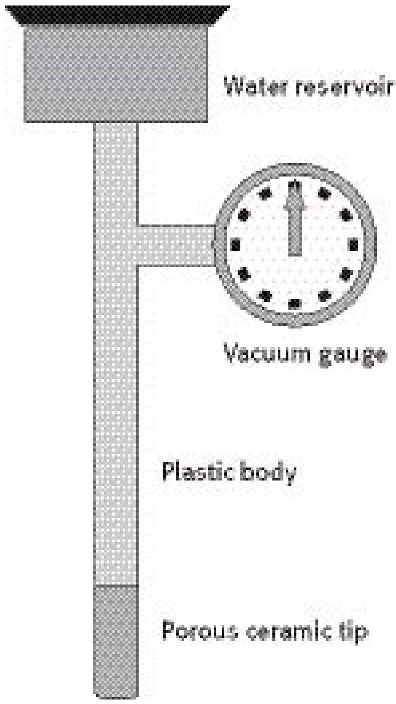


Figure 108 Parts of a standard tensiometer

Tensiometer monitoring sites

Tensiometers are installed at monitoring sites throughout the orchard once trees are established. They are left in place until tree growth requires their relocation further out in the active root zone. Use at least one monitoring site for each tree variety or block.

At each site, install two tensiometers: one shallow and the other deep. Position the shallow tensiometer (300 mm long) in the major root zone with its tip 150 to 200 mm deep, and the deep tensiometer (600 mm long) with its tip 400 to 450 mm deep. Place tensiometers on the north-eastern side of healthy trees, under the canopy and in a location where they will receive an average allocation of water from the mini-sprinklers (Figure 109).

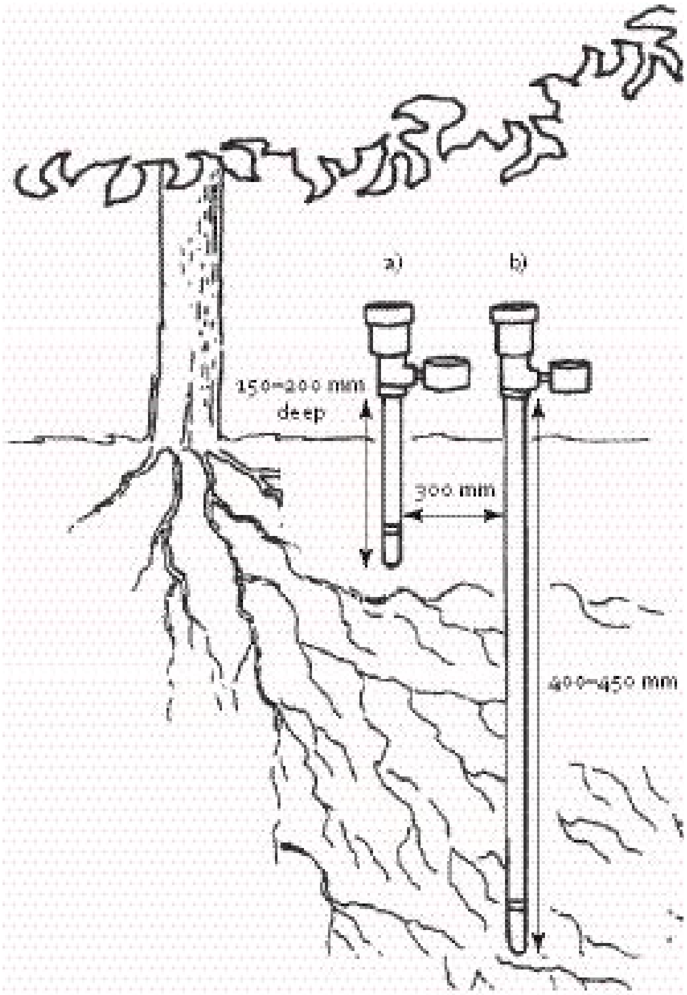


Figure 109 Tensiometer placement in (a) major root zone and (b) below most roots

Installing tensiometers

Assemble the tensiometers and fill them with good quality water to which algaecide has been added. Adding a dye to the water also makes it easier to observe the water level. Leave the tensiometers standing in a bucket of water overnight (preferably for one to two days). The water does not need to be pre-boiled.

Tensiometers will work more reliably if a vacuum pump is used to remove any air from the tensiometer body and gauge. Make sure the pump fits snugly over the fill point on top of the tensiometer. Top up the tensiometers with more water if necessary and use the vacuum pump to remove any air bubbles.

The tensiometers are now ready to install. When installing them, you must ensure that:

- there is good contact between the soil and ceramic tip
- there are no easy pathways for water to flow directly from the soil surface to the tensiometer tip.

Carry tensiometers to the installation site with the tips either in buckets of water or wrapped in wet rags. Do not touch the porcelain tips with your fingers as finger oils can block the fine pores.

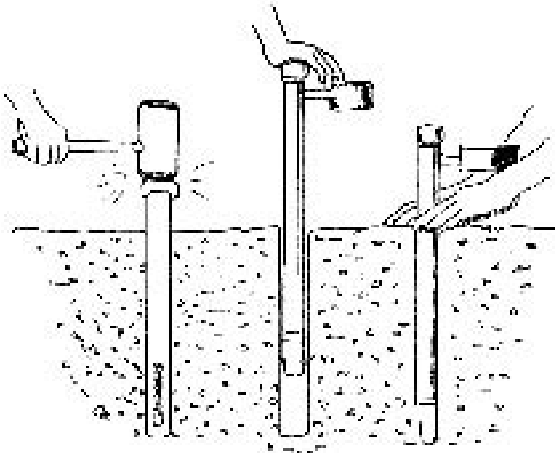


Figure 110 Installing deep tensiometer

Dig a hole to the required depth and reserve the excavated soil. We have found that a 50 mm (two-inch) auger is the best tool. Place the tensiometer in the hole, over to one side (Figure 110).

The next step is critical to ensure good contact between the ceramic tip and the surrounding soil. Take some crumbly, moist soil from the excavated pile and pack it around the tensiometer tip at the base of the hole. A piece of 10 to 15 mm diameter dowel is useful for packing. Do not over-compact the soil, but remove large air gaps. Fill the hole completely with soil.

Friable topsoil can be used to create a slight mound around the tensiometer. This minimises the risk of water draining down beside the tensiometer, leading to false readings.

Covers made from silver/blue insulation foil can be placed over the tensiometers to reduce temperature fluctuations and algal growth. The gauge can be left exposed for easy reading.

The tensiometers are now ready to operate. Use the vacuum pump to remove air bubbles. Tensiometers may take a few irrigation cycles to settle down, so do not rely on the first few days' readings. During this period, air gaps may appear in the tensiometer. Simply refill with algaecide-treated water. Within a week of installation, readings will respond to changes in soil moisture, falling with irrigation or rainfall and rising as the soil dries out.

Clearly mark tensiometer locations to avoid damage from tractors and other orchard equipment.

Reading tensiometers

Read tensiometers at the same time each day, early in the morning, before 8 am; there is little water movement in the soil or plant at this time. Read at least twice a week, but preferably every day. Lightly tap the gauge before reading.

The shallow tensiometer indicates when to water. The deep tensiometer indicates when the right amount of water has been applied.

Irrigating using tensiometers

Start watering when the shallow tensiometer reads 15 kPa (sandy soils) or 30 kPa (loam and clay loam soils). Stop watering when the reading falls to 10 kPa (Figure 111).

If you have not added enough water, readings on the deep tensiometer will continue to rise immediately after irrigation. If you have added too much water, readings on the deep tensiometer will fall to less than 10 kPa soon after irrigation.

Once a week, remove any accumulated air and check that gauges are working using the vacuum pump. Refill tensiometers with clean water.

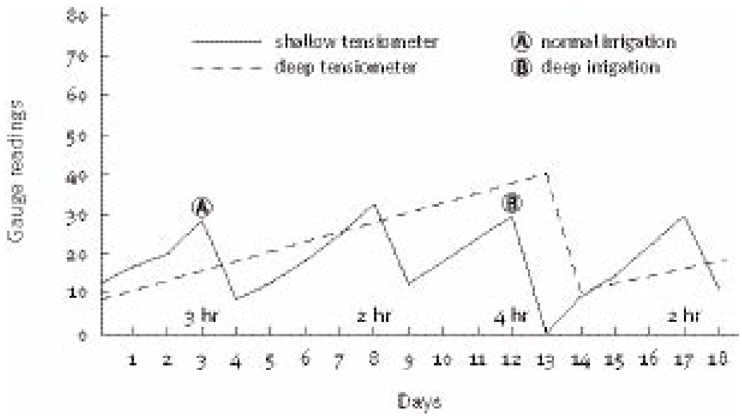


Figure 111 A sample chart showing tensiometer readings on a daily basis

Soil moisture sensors

Soil moisture sensors consist of gypsum blocks which are buried in the soil at strategic points so that they assume the same moisture status as the surrounding soil. A pair of wires hooked to the blocks is left exposed at the soil surface and a digital ohmmeter is connected when a reading is desired. The electrical resistance recorded by the ohmmeter is measured as water tension in centibars (cb) or kilopascals (kPa).

Monitoring sites for the blocks are set up in a similar manner to those for tensiometers, with two blocks at each site: one should be placed at a depth of about 300 mm, and the other at a depth of about 600 mm. Position the blocks in the same way as described for tensiometers.

The gypsum blocks can be installed in holes similar to those used for tensiometers. Again there must be good contact between the blocks and the surrounding soil and the hole filled to the soil surface.

Irrigation scheduling using gypsum blocks is similar to that recommended for tensiometers, as the device is recording the same soil tension readings.

Capacitance probes

Capacitance probes measure the dielectric constant of the soil, which is proportional to its water content. Two types are available: a portable version known as the Gopher or the Diviner, and a non-portable version called the EnviroSCAN or C-Probe.

EnviroSCAN and C-Probe

The EnviroSCAN and C-Probe are continuous moisture-monitoring devices consisting of multiple sensors mounted on probes with slots every 100 mm to accommodate the snap-in sensors.

Probes are then placed within vertical PVC access tubes installed semi-permanently in the orchard. The probes and tubes are generally left in place for the season and then moved to another tube or site as required. However, a probe can be moved from tube to tube to record readings at several different sites.

Sensors are positioned on the probes to provide readings at specific depths. Measurements from the sensors are relayed at set times along a cable to a data logger for recording. Data from the logger are downloaded to a computer every few days to show water use and to provide recommendations for watering.

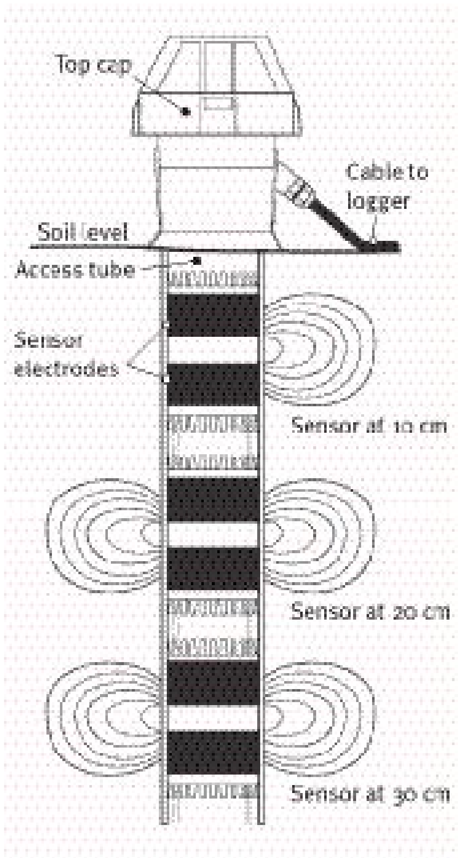


Figure 112 A diagrammatic representation of the EnviroSCAN capacitance probe

A minimum of three probes per block is recommended for sweet persimmon, but the number of sites depends on the variability in soil and tree types. When positioning the probes it is very important to know the water distribution patterns of the mini-sprinklers.

The installation of probes and interpretation of the data requires some skill and we recommend you use consultants to set up the system and provide initial advice. The equipment can also be hired from some consultants.

Evaporation pan

Water requirements can be estimated from evaporation figures. Evaporation figures for your district are available from the Bureau of Meteorology, or for growers in northern New South Wales, from offices of the NSW Department of Agriculture. Figures are also available from local produce stores and newspapers.

Alternatively, you can install a pan evaporimeter and take regular readings. Evaporimeters are relatively cheap and simple to use.

An irrigation ready-reckoner is shown below for growers wishing to use evaporation to schedule irrigation and to estimate long-term water requirements. The system is invaluable for estimating annual irrigation requirements, storage requirements and peak demands.

Table 28 Calculation of water requirements using Class A pan evaporation data

Step	Action	Formula
Step 1	Obtain a set of mean monthly evaporation figures (Epan) for August to March.	Monthly evaporation figures in mm (Epan)
Step 2	As the evaporation figures are generally based on a US Class A evaporation pan, multiply them by 0.85 to convert the figures to the equivalent of evaporation from a free water surface, to give the adjusted evaporation (ETo).	Epan × 0.85 = adjusted evaporation in mm (ETo)
Step 3	Multiply the figure from Step 2 by a crop factor representing the different growth stages of the tree. The suggested crop factors vary from 0.3 in July to 0.7 in October.	(ETo) × crop factor = water use in mm/month
Step 4	Divide the figure from Step 3 by 4 to calculate the approximate water use per week. This equates roughly to the amount of water required from rain or irrigation. Ignore any rainfall of 5 mm or less.	Water use per month ÷ 4 = water use per week in mm
Step 5	Calculate the output of your sprinklers in mm/hour by dividing their output in L/hour by the area of coverage in square metres.	Sprinkler output L/hour ÷ coverage in square metres = sprinkler output in mm/hour
Step 6	Divide the figure from Step 4 by the figure from Step 5 to obtain the number of hours of sprinkler watering per week. Remember that the figure used from Step 4 needs to be adjusted for rainfall before calculation of sprinkler hours.	Water use per week ÷ sprinkler output in mm/hour = sprinkler hours per week

Table 29 Guide to number of irrigations per week

	Clay	Clay loam	Loam	Sandy loam	Sand*
Winter	1	1	1	2	2
Spring	1	2	2	3	7
Summer	2	2	3	4	7
Autumn	1	2	2	3	4

*On the very sandy soils of Western Australia, it is sometimes necessary to irrigate several times a day (refer to the notes on pulse irrigation, page 176).

Irrigation requirements in Australian orchards

Table 30 provides useful data on the irrigation needs of the various growing regions in Australia.

Table 30 Useful data on irrigation requirements for growing regions

Production area	Climate	Estimated annual volume required (ML/ha/yr)	Average yearly rainfall (mm)	Typical highest evaporation loss of the year (mm/week)	Key comments
Mareeba	Monsoonal summer rain, little rain at other times of year.	8	880	35	Sandy soils, regular irrigation. Water is bought from irrigation scheme and supplied by channel or supplement creek.
Atherton	Mainly summer rainfall; some rain every month. Driest period in spring.	6	1300	35	Generally deep soils with good water-holding capacity. Irrigation mainly required as a supplement.
Bundaberg	Mainly summer rainfall, little rain at other times of the year.	8–12	1000	70	Relatively dry. Much of annual rainfall from short intense storms.
Nambour, Alstonville	Mainly summer rainfall; some rain every month. Driest period in spring.	4–5	1750–1800	40–42	Wetter climate with a relatively low irrigation demand. Irrigation required as supplement, particularly in spring.
Sunraysia	Mediterranean (hot dry summers, cool wet winters).	10–12	285	80	Good irrigation monitoring and scheduling essential. Irrigation of total orchard area helps to grow the inter-row sward, reducing the impact of very hot days.
Perth	Mediterranean (hot dry summers, cool wet winters).	15–18	820	62–75	Irrigation essential. On the very sandy soils in this area, trees need to be irrigated several times a day in summer. Pulse irrigation is often practised.
Pemberton	Mediterranean (hot dry summers, cool wet winters).	10	1122	41	Irrigation essential due to hot summers.

Crop load and crop thinning

Thinning is carried out for three reasons—to obtain the optimum fruit size range, to prevent biennial bearing and to optimise long-term profits.

Some considerations for determining the optimum fruit size range are:

- Prices received for different fruit sizes will vary for domestic and export markets.
- The optimum fruit size range will be smaller than the maximum fruit size range that can be achieved.
- Excessively large fruit may also be susceptible to radial cracking and calyx cavity. Consequently marketable yield will be lower.
- Fruit that weigh less than 180g are at the lower limits of marketability.
- Maximising fruit size does not necessarily maximise total income per tree.

Recent surveys of the top sweet persimmon orchards in Australia have shown that high quality fruit can be achieved in most production regions. Within regions, variability in fruit quality parameters is determined more by orchard management than by weather factors.

Orchard management factors which greatly affect fruit size include:

- light interception
- pollination
- leaf health
- tree health.

These factors are discussed in more detail in other sections.

Crop load

Crop load is probably the most important factor affecting fruit size. Adjusting crop load prevents small fruit developing and prevents biennial bearing of the tree.

Guidelines for determining a tree's ideal crop load are based on achieving a set number of fruit per:

- year of age of the tree
- cross-sectional area of tree butt

or

- square metre of canopy surface area.

The last method appears to be the most useful as it measures the productive zone of the tree canopy.

Fruit number per year of age

Guidelines for well-managed Fuyu trees on a palmette trellis spaced 4 m between rows and 3 m between trees within the row are shown overleaf.

Table 31 Rough guide to expected fruit number per tree for trees of different age

Tree age (years)	Fruit number per tree
1–2	0
2	0
3	20–50
4	50–70
5	100–120
6	150–180

Fruit number per cross-sectional area of tree butt

This is a common technique used for estimating crop load of stone fruit and apples. Currently there are no values set for sweet persimmon.

Fruit number per square metre of canopy

Based on studies conducted in Australia and Japan, maximum economic returns on highly managed trees are obtained when about 12 fruit are left per square metre of canopy.

The canopy area of a palmette tree can be calculated from the following formula:

canopy area (m^2) = canopy height (m) × canopy width (m)

A very rough guide for pruning and thinning well-managed, mature pollinated Fuyu trees on a palmette trellis is shown in Table 32. The aim is to determine how many fruiting laterals are needed per sub-leader to achieve the required fruit size and yield.

Table 32 Rough guide for pruning and thinning well-managed, mature pollinated Fuyu trees

Crop load (fruit no. per square metre of canopy)	Estimated fruit size (g)	No. of fruit per tree	No. of sub-leaders (four on each side)*	Average no. of fruit per sub-leader	Rough no. of fruiting laterals and sub-laterals per sub-leader	No. of fruit per fruiting lateral and sub-lateral
8	280	80	8	10	10	1
10	260	100	8	13	12	1
12	240	120	8	15	15	1
15	220	150	8	19	15	1–2

*Palmette only. Surface area is calculated by multiplying height of tree by width of tree. This example is for mature trees 3.6 m high with a width of 3 m (i.e. 3.6 m x 3.0 m to give approximately 11 m^2 of surface area).

Thinning method

Time of thinning

Japanese research has shown that the earlier fruit is thinned, the larger the final fruit size and the less likely the chance of biennial bearing. Most varieties exhibit two fruit drop periods, the first within two to three weeks after set, and the second four to six weeks later.

The first fruit drop is normally the largest. In Japan, some varieties are disbudded or flower thinned. Often these varieties are hand-pollinated to ensure adequate set. Flower thinning should only be carried out on well-managed trees, where there is no likelihood of significant fruit drop after set; otherwise the risk may be too great.

Factors that cause significant fruit drop include:

- cloudy conditions during fruit set
- excessive nitrogen application and plant growth
- severe pruning
- severe water stress.

Poorly pollinated fruit are likely to drop first. These factors have been discussed in detail in other sections.

We suggest the following thinning times for orchards with:

- all well pollinated fruit—a single thin about two weeks after full flowering
- non-pollinated fruit or a mixture of both well pollinated and poorly pollinated fruit—an initial light thin within two weeks of full flowering and a final thin within three to four weeks after fruit set.

Some growers leave thinning until January, because of concern about the amount of fruit drop.

Thinning practice

When deciding which fruitlets to thin and how many fruit to leave per sub-lateral, growers should consider the following:

- Fruit set is usually higher, and fruit are larger, in the more exposed parts of the tree canopy such as the top, and the north and east sides.
- Larger flower and fruitlets produce larger fruit.
- Later set flowers produce smaller fruit.
- The base diameter of laterals is moderately correlated with final fruit size.
- Fruitlets with damaged calyxes or any other damage or blemish should be removed.
- One to two fruit (well separated) should be left per fruiting lateral.
- Fruit left should hang horizontally—fruit that hang vertically side-on to the sun are prone to sunburn.

Although chemical thinning is practised in Japan, it has not been trialled in Australia.

Monitoring

Growers should keep good records of:

- fruit size grades
- prices per size grade
- thinning intensity (number of fruit per square metre of canopy surface area)
- leaf health, nutrition and nitrogen levels
- light penetration into canopy
- balance of fruiting versus non-fruiting wood (70:30)
- fertiliser program.

Pruning and training mature trees

NOTE

It is important not to over-prune younger trees (especially the variety Jiro) as this may slow development of tree structure and reduce early cropping.

Young trees require pruning to achieve a desirable structure; mature trees must be pruned to achieve a balance between fruiting and renewal sub-laterals on which the following year's crop will be carried. Once trees are four to five years of age, they should be at 90% of their maximum yield potential. Specialised pruning techniques are needed at this stage to maintain productivity.

Winter dormant pruning of mature trees

Before starting any winter pruning, you must be able to identify the type and position of vegetative and floral buds on the laterals (Figure 113). In Australia most laterals carry fruitful buds along 70% of their length, except for the basal three to four buds. The best quality fruiting wood has a thick base diameter and is usually 300 to 400 mm long.

(a)

(b)

Figure 113 (a) Vegetative and (b) floral buds

Ideally, there should be balance between fruiting and non-fruiting wood. If trees are pruned too hard this will increase the number of non-fruiting laterals at the expense of fruiting laterals. Similarly, over-cropping will increase the number of non-fruiting laterals and induce biennial bearing. Fruiting and non-fruiting sub-laterals should be counted before dormant pruning to give an indication of the size of the coming season's crop.

Laterals or branches with sub-laterals should be equally spaced along the sub-leader at intervals of about 100 mm. This will help to control vigour, maximise production and prevent shoots rubbing against the fruit.

Winter pruning is normally done in late dormancy, for example in July–August about four to six weeks prior to bud break. If pruning is done too early, bud break is reduced and fewer laterals produced.

Winter Pruning Practices

Winter pruning involves:

- removal of very weak or dead laterals less than 100 mm in length which have fruited the previous season
- complete removal or heading back of very strong water shoots to four to six basal buds (spurs); spurs pruned to fewer than six basal buds may die. Alternatively, water shoots may be laid down along the wire to generate new sub-leaders especially where there are gaps in the canopy

- removal of vertical shoots along the sub-leaders, to reduce the amount of strong vigorous growth and shading. Aim for fewer upright laterals and sub-laterals
- tipping of strong fruiting laterals that are between 300 to 400 mm long
- removal of branches arising from the sub-leaders which are greater than one-third the diameter of the sub-leader. These are usually branches that are three to four years old. This practice is essential to let light into the tree and to stimulate growth of dormant buds
- heading back or bending strong shoots in the upper levels of the tree to weaker side laterals to control tree height
- tipping horizontal sub-leader terminal shoots to downward buds, to prevent shoots from adjacent trees growing into each other along the wire.

Summer pruning of mature trees

Summer pruning may help improve light penetration and stop excessive vegetative growth. However summer pruning may increase sunburn and, if done too early, induce unwanted regrowth and stimulate fruit drop.

Summer pruning is carried out in late November in Queensland, and in late December in South Australia and Victoria.

Summer pruning practice

- Strong water shoots are removed completely during the early vegetative flushing period in early summer. It is preferable to remove these water shoots during this period rather than wait until dormant pruning in July, because the adverse effects of severe competition with developing fruitlets and internal tree shading will already be apparent.
- Tipping of moderately vigorous shoots during the summer period may be detrimental as it may induce multiple shooting and subsequently cause excessive shading.
- Some growers have found that it is better to bend over upright vigorous shoots at the top of the tree, rather than pruning them off. This helps to dissipate the energy, prevents strong multiple shoot regrowth and increases flower initiation. It is important to time this practice to avoid branch breakage.

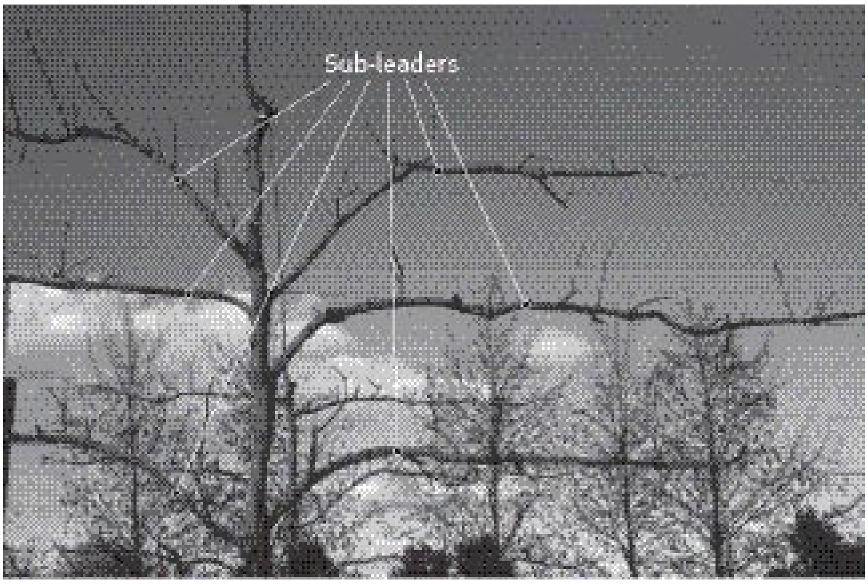


Figure 114 Pruned horizontal palmette, showing horizontal sub-leader training (see above). Note six sub-leaders—three on each side

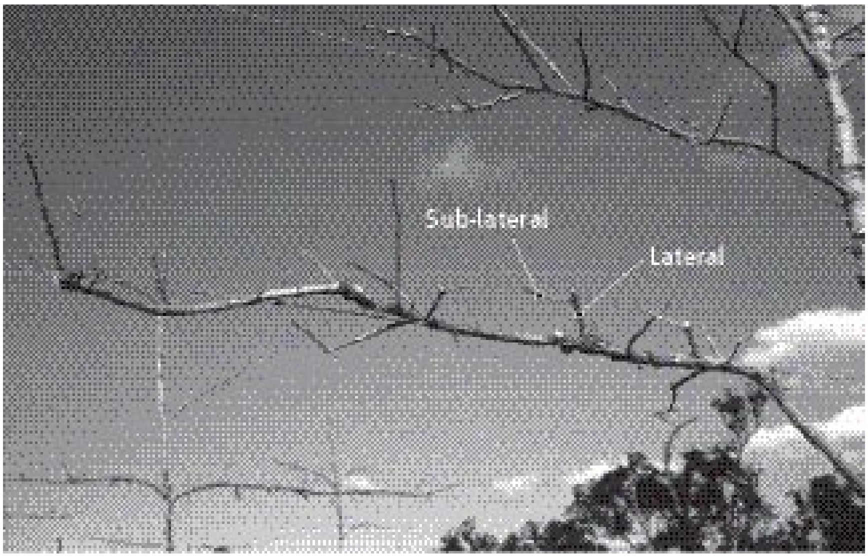


Figure 115 Sub-leaders pruned to short laterals and sub-laterals (about 20 on each sub-leader). Remove shoots that will grow vertically

Pest and disease management

Managing insect pests and diseases is an important part of growing sweet persimmons. There are several serious pests and diseases, and a few have the potential to seriously affect fruit yield and quality. Among the most important are mealybug, fruit fly, fruitspotting bug, caterpillars, aphids, clearwing moth borer, and Cercospora leaf spot.

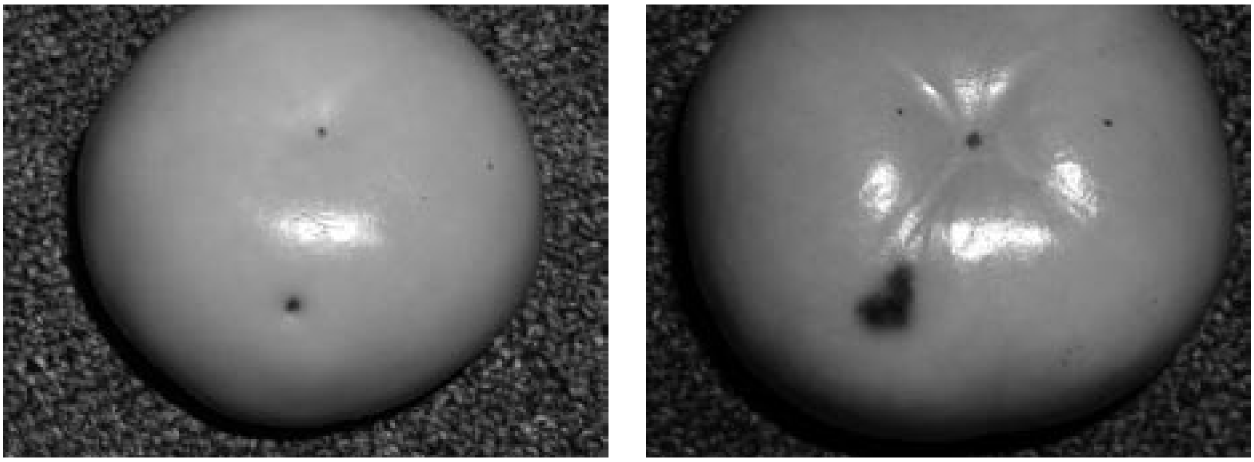


Figure 116 Fruit showing Queensland fruit fly egg laying sites

Approaches to pest management

There are fundamental differences between the management of insects and mites and the management of diseases. These must be understood when developing management strategies.

The traditional approach to insect pest control

The traditional approach to insect and mite pest control was to spray crops at regular intervals whether or not pests were evident. This approach:

- was costly and a waste of money if pests were absent.
- did not take into account the fact that small numbers of pests can be tolerated without significant effect on yield and quality. In these cases, the cost of spraying is much greater than the benefit gained by controlling the pest
- increased the risk of chemical damage to the fruit
- relied heavily on new chemicals being developed to replace those to which insects had developed resistance
- killed beneficial insects and mites, and sometimes resulted in outbreaks of pests that were well controlled naturally
- exposed farm families and farm employees to a range of toxic chemicals
- had the potential to increase chemical residues in fruit and the wider environment.

The modern approach to insect pest control—IPM

The modern approach to insect pest control uses complementary control measures to reduce chemical use. This approach, called Integrated Pest Management (IPM), has a number of key elements, including:

- cultural control measures such as crop hygiene and crop rotation
- biological control measures such as naturally occurring or introduced parasites, predators and pathogens (known as natural enemies or beneficials)
- reduced chemical use—chemicals are used only when necessary and 'softer' chemicals, which do less harm to beneficial insects and the environment, are preferred
- careful application of chemicals with well-calibrated spray equipment to avoid crop damage, excess residues and off-site pollution
- regular monitoring to determine when pests are present.

In IPM, pest populations are regularly monitored and control measures applied only when pests approach or reach pest action levels. An action level can be thought of as the point at which damage caused by the pest is roughly equivalent to the cost of control.

Monitoring then continues to allow pest populations to be managed at or below this action level.

Beneficial insects and mites, which naturally attack pests, are also monitored. In some cases, these beneficials will be sufficient to keep the pest populations in check.

IPM is not without risks. It works best in the following situations:

- dry inland areas where pest pressures are lower
- areas where pest consultants or skilled monitors are available to do the monitoring and provide on-the-spot technical advice.

Growers must be dedicated to IPM ideals and prepared to accept the occasional failure inherent in a biological control system.

The managed spraying alternative

Even if you cannot follow the complete IPM system, you can reduce chemical spraying by using some IPM strategies. This managed spraying approach is the one we recommend for pest control in sweet persimmon. It uses the following strategies:

- monitoring pest populations as outlined for IPM
- using chemicals only when action levels are reached
- preferring chemicals that are less harmful to naturally occurring beneficials
- carefully applying chemicals with well-calibrated spray equipment so that maximum impact is achieved with each spray.

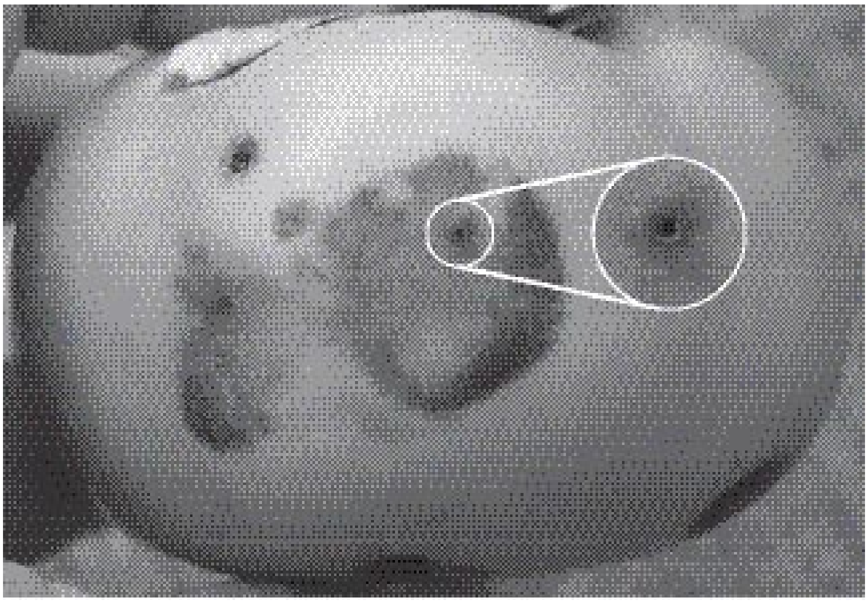


Figure 117 Fruit showing feeding site of fruitpiercing moth. This large moth is active at night and is difficult to control

Disease control

Diseases are much more difficult to monitor than insect pests. A disease is microscopic and in most cases, is well established and difficult to control by the time symptoms are noticed. We therefore rely on preventive sprays to control most disease problems.

Monitoring is still useful for detecting obvious problem areas and for evaluating how well a disease prevention program is working.

Pest monitoring

Pest monitoring is important, whether you are following the IPM or managed spraying approach. Because successful monitoring requires considerable training and skill, we recommend you use professional pest monitoring services.

These consultants will visit your orchard about every 7–10 days during the main part of the season to monitor pest populations. After each visit, the pest consultant will provide a report on pest status and the required sprays. The cost of using a pest consultant varies according to planting density, pest and disease status of the orchard, and other factors.

If you wish to do the monitoring yourself, we suggest you first get some training from a pest consultant. Here are the main requirements for monitoring.

Materials

- Hand lens (×10), magnifying glass or small microscope
- Notebook, prepared monitoring charts and pen
- Plastic bags or small bottles and marking pen for samples
- Sharp pocket knife
- Roll of coloured plastic tape

Other

- Commitment and the time to do regular monitoring at least every 14 days (7 days for fruit fly)
- Good eyesight
- Good knowledge of pests and beneficial insects and mites
- Commonsense

Monitoring is not difficult. It is a process of systematic observation and recording.

How many trees to monitor

Divide your orchard into monitoring blocks, each consisting of trees of the same variety and of similar age. Each block should be monitored separately. If your entire orchard consists of trees of the same variety and age, it can be treated as one block.

For most pests, closely examine at least 20–30 trees in every hectare of each block. If a block is less than one hectare, check at least 10–20 trees in that block. Planting density does not affect the number of trees that must be monitored.

When and how often to monitor

While monitoring is useful at all times of the year, the critical period is from September to June. Monitor at fortnightly intervals for mealybug, scales, ants and diseases. Fruit fly traps need to be monitored at weekly intervals. Fruit flies generally become more active in late January and February. Monitor one-year old laterals for scale during October and November. Take special care to observe trees for clearwing moth larvae activity.

Monitoring procedure

Prepare some monitoring charts to record your results. An example is shown on page 198.

Each time you monitor, select trees randomly but from different parts of the block. While moving between these selected trees, keep alert and visually scan intervening trees. It is best to do the monitoring on foot, as trees must be inspected thoroughly.

Inspect ten fruit selected at random from each of the trees being monitored. Use your hand lens if necessary. The fruit do not have to be picked unless they are damaged by spotting bug or severely damaged by other pests.

Inspect each sampled tree for signs of pest activity and damage to leaves, twigs, branches or fruit. Look for clearwing moth caterpillar damage to bark and wood. If you have collected samples for later examination in the shed or office, place them in a plastic bag inside an esky. Mark the sample with the block number and date.

Monitor fruit fly separately using lure traps. Q-lure traps are designed to attract male flies of some species only. They will attract male flies from approximately 500 m distance. Place the trap in the middle of each block, not near the edge. Collect and count male flies each week, and look for a sharp increase in numbers (for example a jump from 10 flies per week to 100 or more flies per week).

Clearwing moths can be monitored or controlled. Special pheromones attract male moths only, and can give some idea of moth activity. However, when pheromones are used for mating disruption, no moths should be found in traps. The principle behind this is that when the orchard is 'saturated' with pheromones, the males cannot find females, and mating does not occur within the orchard.

After each monitoring session, transfer the results of your monitoring charts to an orchard record. This will provide a permanent record of trends for each pest and beneficial insect over the season, and will become a valuable source of information as you record data over several years.

Figure 118 Clearwing moth borer may be controlled with pheromones, which disrupt mating in the moths. This small tube dispenses pheromones and is placed in the orchard among the trees

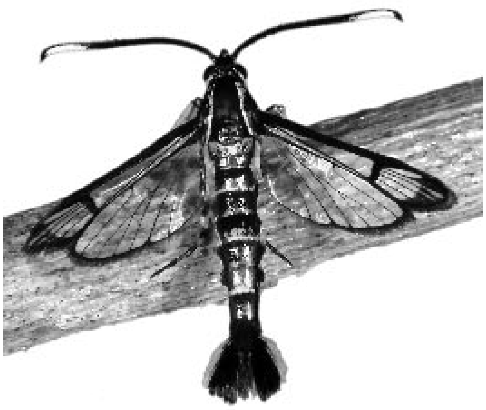


Figure 119 Clearwing moth caterpillars cause extensive damage to trees by tunnelling in wood and feeding on bark. This pest is difficult to control. Key activity periods are September to May.

Pest monitoring chart

Orchard:

Block: Date:

Tree no	Pest or disease								Beneficials		
	FSB	MB	A	QFF	S	LR, OFB	CM	FPM	L	C	W
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
TOTAL											
%											

KEY:

Pest or disease:

A – Ants
CM – Clearwing moth
FPM – Fruitpiercing moth
FSB – Fruitspotting bugs
LR – Leaf roller
MB – Mealybugs
OFB – Orange fruit borer
QFF – Queensland fruit fly
S – Scales

Beneficials:

C – Cryptolaemus ladybird
L – Leptomastix wasp
W – Lacewings

Insert other appropriate column headings. Record the number of fruit infested for each tree. For scale, record if the tree is infested. For beneficials, record the number of fruit with beneficials.

NOTE
Details of pesticides registered for the control of pests and diseases are given in Chapter 6 page 231.

Pest management in practice

Fruit fly is one of the most important pests. Bait spraying (a combination of an insecticide in small quantities and a yeast attractant) must commence about six weeks before fruit start to develop a hint of yellow colour, and must be repeated weekly. This program aims to reduce flies to a low level and keep them at that level during the fruit ripening phase.

An alternative approach to fruit fly control is to use systemic cover sprays. The timing of such sprays depends very much on catches of flies in the lure traps. For example a dramatic increase in trap fly counts may require a cover spray.

Some fine mesh netting can also be used to exclude insects such as fruit fly.

Clearwing moth is an increasingly serious pest, which is now found in Victoria as well as in Queensland. It is a very difficult insect to control, as caterpillars feed under bark, especially around tree crotches. Fuyu appears to be quite susceptible to clearwing moth.

Pheromone mating disruption is one option for the control of clearwing moth. While the initial recommendation was for one application per year, two applications are preferred. The pheromone twist-tie dispensers should be applied at a rate of 1000 per hectare. As each 1000 dispensers cost about $400, the cost of control is about $800 per hectare, when two applications are made. Some growers have found pheromones to be highly successful (especially under netting), while others have had less success. Further work is required.

Pesticide safety

Most pesticides should be considered potentially hazardous. However, simple safety precautions can eliminate these hazards.

- Always read the label before handling.
- Obtain, study and have on hand for emergencies the Material Safety Data Sheet for each chemical you use (suppliers of chemicals are legally required to supply these).
- Use chemicals only as directed.
- Follow the label safety directions, including the use of safety equipment.
- Be aware of how poisons can enter the body.
- Keep all chemicals in a secure location.
- Store chemicals in original containers only.
- Dispose of empty containers immediately and correctly.

Pesticides and the environment

See consultant list for sprayer calibration specialists, Chapter 5 page 215

Always consider the environment when you are applying pesticides. There are four main ways in which pesticides can pose a threat to the environment:

1. Spray drift. This is usually the result of incorrect sprayer set-up or calibration (or sprayer type), or of spraying during inappropriate weather conditions. Calibrate your sprayer regularly.
2. Excessive spray runoff. This is also usually the result of incorrect sprayer set-up or calibration (or sprayer type), or of spraying during inappropriate weather conditions.

3. Inappropriate disposal of excess chemical (both concentrate and diluted) or empty containers. There are documented methods for safely disposing of pesticides and their containers. These can vary from state to state and some are legal requirements. All growers should be aware of their own local disposal regulations. Do not use empty pesticide containers for any other purpose.
4. Inappropriate location of pesticide storage sheds, and fill-up and wash-down areas. The possibility of a spill occurring should be considered when locating these areas. An example of a potential hazard is locating these areas next to your water source, which could become contaminated in the event of a spill. If you must store chemicals close to a water source then ensure precautions are in place to contain and handle any spill.

Figure 120 Machine used to apply fruit fly bait sprays. Many areas of southern Australia are free of fruit fly, and this status is carefully protected

How pesticides enter the body

Dermal exposure (direct contact with the skin and absorption). Liquids are particularly hazardous and can lead to acute poisoning, especially when pesticide concentrate is handled (i.e. when mixing). Long-term exposure to chemicals as a result of spray drift or contact with recently sprayed plants can also lead to chronic poisoning. Dermal poisoning occurs when inadequate protective clothing is worn.

Inhalation. Inhaling chemicals, particularly dusts and fumigation vapours, can lead to acute (short-term and severe) poisoning and chronic (continuing over a long time) poisoning. Inhalation poisoning occurs when a suitable, properly maintained respirator is not worn.

Swallowing. Children under the age of five are most at risk of swallowing poisons, usually as a result of inadequate storage security or improper disposal of empty containers. Another often forgotten way that poison is ingested is by eating fruit too soon after pesticide application, which over time can lead to chronic poisoning. This is a result of not reading or following the label safety directions, in particular the withholding period.

Common symptoms of poisoning

Acute poisoning symptoms often start within a few hours of exposure. Mild symptoms can include nausea, anxiety, sweating, and salivation; more severe symptoms can include vomiting, abdominal cramps, diarrhoea, urinary incontinence, vision impairments and respiratory difficulty.

Chronic poisoning is much more insidious as symptoms often do not show up until some time after exposure.

Harvesting and storage

General quality characteristics

The skin colour of sweet persimmons varies from yellow to orange; this colour development is partially dependent on temperatures experienced during maturation of the fruit on the tree. Fruit should be medium to large in size and firm (penetration force greater than 2.3 kg when an 8 mm tip is used). Fruit should also be free of growth cracks, mechanical injuries, disease, pest damage and signs of breakdown.

Minimum total soluble solid levels (TSS or Brix) in Fuyu should be 14%. Sweet cultivars should have no astringency (i.e. zero tannin content).

Size is important, especially if fruit is being exported. A desirable size for Fuyu is 230 to 250 g, with 180 g required as a minimum marketable size.

Nutritional characteristics

Sweet persimmons fruit are a good source of carotenoids, vitamin A, vitamin C and dietary fibre.

Maturity indices

Minimum maturity is based on skin colour change from green to orange, or to yellowish-green or yellow (Fuyu, Jiro).

Harvesting, sizes and packaging

Several picks are required to harvest the crop.

1. Harvest in the early morning. The best method of harvesting is to clip fruit from the tree with small secateurs, leaving the calyx attached to the fruit. The stem should be cut off as close to the fruit as possible. It is possible to snap the fruit from the tree, but this practice is not recommended, as it may damage the fruit and the shoot. Fruit must be handled very carefully to avoid bruising, which becomes unsightly as the fruit ripens.
2. Cool fruit down after harvest in a forced-air coldroom or similar to about 12°C.
3. Dip fruit if required.
4. Carefully place or tip fruit onto grading machine and pass over soft brush rollers.
5. Pack and grade sorted fruit.
6. Place packed fruit back into coldroom.
7. Place fruit in refrigerated truck with a temperature of about 12°C.

Optimum storage conditions

Growers need to distinguish between short-term and long-term storage.

Short-term storage. Fruit is pre-cooled, packed, freighted and sold within a few days of harvest.

Long-term storage. In countries such as New Zealand and Japan, fruit is often exported in modified atmosphere bags in sea containers and may be held for one to three months before being sold. In Australia, long-term storage has not yet proven to be a viable option. On the contrary, fruit harvested from wetter coastal regions may have a reduced storage life, even if held at the correct temperatures. In this case storage life may be as short as one week.

Optimum temperature

Optimum storage temperature if fruit is to be held for more than one to two weeks is 0°C. Freezing point is about –2°C, depending on sugar levels. Fuyu and other sweet cultivars are chilling sensitive at temperatures between 2°C and 15°C. Exposure to ethylene in storage is a significant problem as it speeds the softening process, thus markedly reducing shelf life, and aggravates chilling injury at these temperatures.

Relative humidity

90% to 95% relative humidity is recommended.

Controlled atmosphere considerations

In theory, post-harvest life under optimum temperature and relative humidity in ethylene free air can be up to three months. Under controlled atmosphere conditions, it may be extended to five months. Neither of these levels of storability has yet been reliably demonstrated to apply to sweet persimmons grown under Australian conditions.

Rates of ethylene exposure

Persimmons are very sensitive to the presence of ethylene. Exposure to small amounts of ethylene can accelerate ripening to soft fruit in two days.

Physiological disorders

Chilling injury

Chilling injury can cause a major loss of quality in sweet persimmon. The extent of chilling injury is related to variety, post-harvest storage temperature and the length of time that the fruit is stored under given temperatures. Chilling injury is marked by flesh browning, softening of fruit, and a water-soaked appearance.

Symptom development is slowest at 0°C, which is the recommended temperature for long-term storage and transport. Please note that fruit, particularly from orchards in wetter, lower calcium coastal soils, may not be suited for long-term storage, and have a short storage life regardless of temperature. Most chilling injury occurs between 2°C and 15°C. It is fastest between 5°C to 7°C.

The current recommendation is to store fruit at either 0°C, or about 12°C, and to keep it for as short a period as possible before selling it. For fruit destined for local markets, there is usually no need for storage at 0°C.

It should be pointed out, however, that further research in the area of post-harvest storage temperature for Australian sweet persimmon is urgently required.

Figure 121 Harvesting sweet persimmon

Figure 122 Sweet persimmon packing shed

Propagation

Grafting or budding of selected varieties onto seedling rootstock species is the usual method of propagating sweet persimmon. Grafting is more successful than budding.

Scion wood for grafting should only be selected from trees of known performance and the use of specific rootstock varieties is desirable. Where a covered propagation shed is used, grafted plants ready to be field planted can be produced in about 12 months. Otherwise, the process can take 18 months.

Container grown plants are probably easier to manage and handle than those grown in nursery beds. Sweet persimmon seedlings are highly susceptible to transplant shock. A suggested method of propagation which avoids this problem is to pre-germinate seed and then raise the seedlings in larger polybags.

Seed extraction and preparation

Seed germination is generally high, provided the seed is extracted from mature but not soft fruit in autumn. Best germination results are achieved from fruit that is firm to soft, but not decomposed.

Seed is usually extracted by hand and adhering flesh removed by washing with water. Treat seed using domestic bleach (5 or 10mL of 4% chlorine per litre of water) for five minutes followed by a Benlate fungicide dip (1g/L) for five minutes, and a Thiram fungicide dip (1.5g/L) for five minutes. Seed affected with blue/green fungal mould should be removed and destroyed.

Seed should be planted immediately. Do not allow seed to dry out. If seed is allowed to dry then stratification is necessary. It is best to stratify using slightly damp (not wet) sawdust, peat, vermiculite or a 50:50 mix of vermiculite and perlite sealed in an airtight plastic bag or container. The containers are then placed in a refrigerator between 1°C to 6°C for two to three months. Cutting open a small quantity of seed and viewing the endosperm to ensure it is a healthy white colour is a common method for checking seed viability.

Figure 123 Top working older trees to new varieties is not difficult, and can be an alternative to removing older trees and planting young trees

Seed germination

Seed which is still moist requires no stratification, but the germination period is highly variable compared to stratified seed where the germination period is shortened. Treat seed with a registered inoculant such as No Gall before planting. Seed germination is best under ambient conditions (28°C/10°C day/night).

Temperature fluctuations provide a higher germination percentage. Seed that will not germinate quickly can be stratified and again re-germinated with a high degree of success. Some seed need a greater chill period to break this seed dormancy factor.

Seed can be pre-germinated in slightly moistened sterilised sawdust, peat or vermiculite, held in plastic bags or between hessian bagging. If using hessian, sterilise with chlorine to decontaminate and leave to air before use.

Seed may also be planted directly into polybags or Easyouts/tubes but replanting is necessary where seed fail to germinate.

Prick out seedlings at two-leaf cotyledon stage and plant into Easyouts, groove tube air-root pruners or polybags (heat root zone only to 28°C to 32°C). Easyout tubes or groove tube air-root pruners have proven to be the most successful containers used to date for promotion of straight robust root systems.

Two to three months after germination, seedlings can be transplanted into polybags. Some varieties have different seed dormancy requirements, and trials are needed to identify the changes in techniques required to improve germination percentages. If temperatures fall too low at night, germination can be affected; germination is best carried out in a hothouse or under shelter where temperatures do not drop below 10°C.

Preparing rootstocks

Rootstock trees should be well grown and continuous growth flushes must be maintained with adequate temperatures, good nutrition and irrigation. Poor growing conditions will restrict sap flow and produce shortened internodes making it difficult to find a clear space for budding or grafting. Stocks from pencil thickness to little finger thickness are ideal for budding and grafting. Smaller and larger stocks are more difficult to handle and grafting success is often not as good.

Potting mixes

Potting mixes should be friable to allow adequate drainage and air filled porosity for root growth. Polybags (5 to 7 L tall bags) are the best as they produce a substantial straight root system. Small quantities of fertiliser are added to the potting media to avoid damage of the root system.

Lime is applied to adjust pH of the media to 6.0–6.5. Once seedlings are planted and establishing in containers, apply slow release fertilisers such as Osmocote along with regular foliar fertilising (once a fortnight) to maximise leaf nitrogen levels for the highest seedling growth.

Suggested potting mix. Mix equal parts peat and sand. To each cubic metre of mix add a small quantity of fertiliser such as the following:

- 7 kg of 8–9 month slow-release fertiliser (e.g. Osmocote or Nutricote)
- 6 kg of dolomite
- 1 kg of DAP
- 1 kg of trace element mixture (Trace).

The potting mix should be pasteurised or sterilised at 60°C.

Watering

Irrigation must be available during propagation. Irrigation before propagation ensures good sap flow and easy-lifting bark, and irrigation soon after propagating ensures continued sap flow and a good bud take.

Keep the rootstocks well watered at all stages but pay particular attention to watering at propagating time, especially for early propagation when the stocks are smaller. A 10 to 20 mm layer of sawdust or suitable mulch should be applied to the surface to stop it drying out and this will also suppress weed growth within the container.

Preparing the stock

A clear section of about 100 mm is required on the stock for grafting or budding. Leaves and side shoots are removed and the tree is budded at 100 to 150 mm above the ground. It is possible to prepare the stocks much earlier by rubbing and removing young shoots and leaves from the budding position, making the budding operation a little easier at budding time.

Propagation

Scions taken from vigorous healthy shoots of the previous season's growth are collected during the dormant phase, stored slightly moist (but not wet) in airtight polyethylene bags, at about 0°C to 2°C, until they are used for grafting. Dormant scions are used, and providing grafting is done at the opportune time, a success rate of more than 90% can be achieved.

Dormant propagation (winter grafting)

Side cleft, side top cleft, whip, side veneer graft, T-patch and chip budding can be carried out on seedlings in Australia from August to September (late winter early spring). Side cleft and side top cleft grafts offer advantages in that scion wood does not have to match in thickness (as with whip grafting) to achieve a highly successful result.

Seedlings are generally grafted when they reach a height of about 500 mm tall or above and pencil thickness in diameter. Once grafted or budded the scion/rootstock union site is painted with white or brown water-based paint with a commercial anti-transpirant (pruning and grafting mastic) and PVA wood glue mixture.

If temperatures are low during propagation then a dark coloured sealant is used to absorb heat, but if temperatures are high a light colour is used to reflect heat. Higher success rates are achieved under warm conditions (20°C to 25°C), which enhance rapid callusing.

It is critical to seal the union site to prevent drying and moisture penetration. Heavy rainfall during this phase can facilitate the entry of disease organisms resulting in a low rate of success.

If the scion is not covered with an anti-transpirant sealant, it should be covered with a small plastic bag to stop moisture loss from the scion. A white paper bag is then placed over this plastic bag to stop excessive heat build-up.

Hardwood grafting (spring grafting)

T-budding, chip, patch budding, and side cleft grafting in September to early December (late spring to beginning of summer) have also proven successful in New Zealand and Australia with sweet persimmons. At this time, the stocks are just coming into leaf and growing. Stored hard bud wood is used.

The union is covered completely with grafting tape to prevent drying and painted with white water-based paint mixed with a commercial anti-transpirant compound and PVA wood glue mixture.

Figure 124 T-bud

After the buds or scion are inserted, the stock is cut back or bent over and then progressively cut back (do not cut right back to the bud until the union is complete and the bud has grown). This technique is particularly useful when scion wood is in short supply, and is a good method to multiply material.

Green grafting (semi-softwood grafting late summer to early autumn)

Green grafting in summer (late January, February and March in Australia and New Zealand) is also successful. However, plants grafted very late do not make much growth before autumn, unless they are grown during winter in a glasshouse. Semi-hard green graft wood, which has been pre-conditioned, must be used. The graft wood is prepared by tipping and removing a leaf from a shoot while still on the tree. These shoots are removed seven to ten days later for budding.

Cincturing of the shoot may also be advantageous in increasing the graft wood starch reserves before propagating. T-budding, chip budding and side cleft grafting have proven successful during this period. Only the union is painted to seal it. Side veneer and whip grafting have not been as successful. These grafts have to be enclosed in a plastic bag then covered with a white paper bag to stop heat build-up.

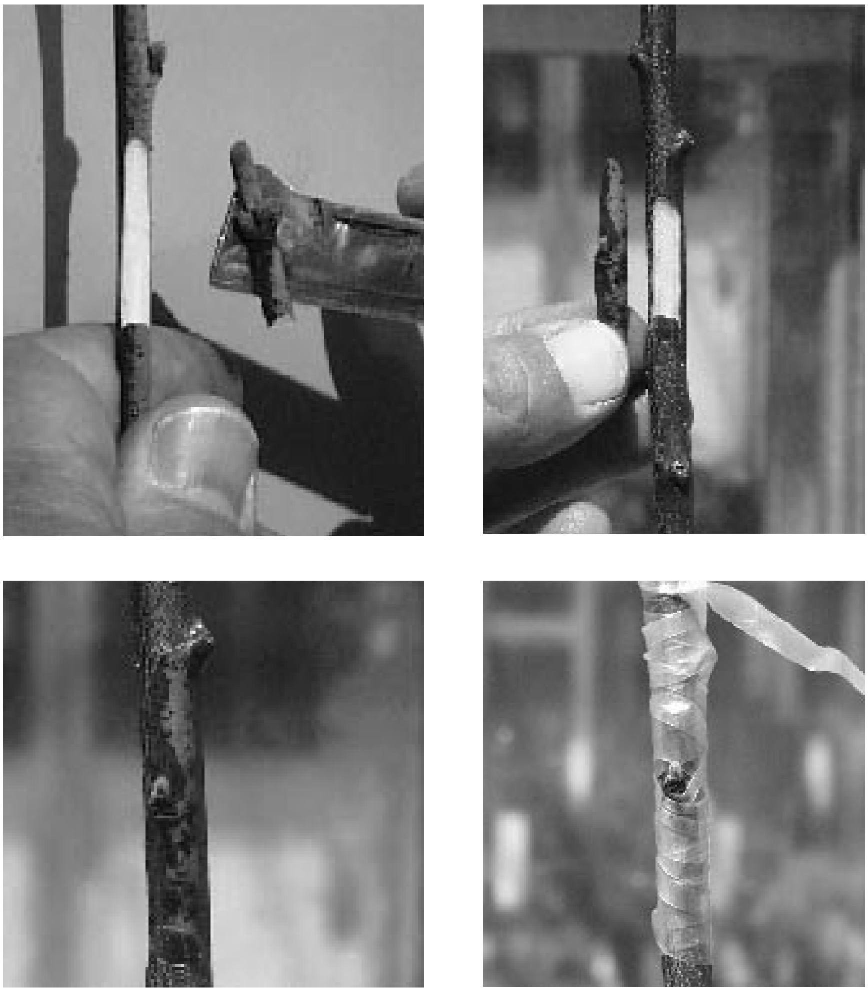


Figure 125 Chip bud

After the buds or scion are inserted, the stock is cut back or bent over and then progressively cut back (do not cut right back to the bud until the union is complete and the bud has grown). This technique is particularly useful when scion wood is in short supply and is a good method to multiply material.

Semi hardwood grafting (late autumn to early winter)

Semi-hardwood and hardwood propagating in the autumn period is successful, but trees do not make substantial growth before going into winter dormancy. Chip budding and T-budding are more successful during this period when compared to side cleft, cleft and whip grafts. To keep plants actively growing during winter requires heated glasshouses with day/night temperature maintained between 28°C and 15°C, and regular watering and fertilising of trees.

Always leave the heel of the scion just above where the stock has been cut off so callus tissue can grow over the rootstock and seal it off thus providing a solid union.

Cleft, side, or whip grafts can be used, again with two-bud scions (stored scion wood is used). The graft union and all cuts, including the tip end of the scions, should be thoroughly covered with grafting wax. Although bud movement is sometimes delayed after top grafting, very vigorous growth (which requires supporting) is normally produced.

Figure 126 Whip graft

Cuttings

Clonal propagation techniques using cuttings and tissue culture are being developed in New Zealand. Good success has been obtained in rooting leafy green wood summer cuttings taken from forced *D. kaki* seedlings (very juvenile material), but the number of cuttings that can be obtained is limited due to lack of available material.

A single node cutting is taken and placed under misting. The base of the cuttings is treated with 1000 ppm IBA (in 50% alcohol) before placement in a coarse sand mist bed with bottom heat (temperature 20°C). Cuttings will start rooting from four weeks on and should be removed as they root, transplanted into polybags and grown in a heated hothouse for the rest of the season, then grafted in spring.

Root cuttings are successful but sufficient trees from which to remove cuttings of a desired rootstock are needed. Root cuttings 50 mm long and 5 to 20 mm in diameter are taken in May and placed in moist sand or a 50:50 vermiculite perlite mixture in polystyrene boxes and kept at ambient air temperature.

Rooting usually takes two to four months and each cutting will send out multiple shoots, which need to be sectioned and transplanted into polybags.

After care of grafted/budded trees

Because of the number of operations in the grafting techniques, it is advisable to have a second person to apply the sealing compound or protective covers. Trees should be sheltered as soon as possible. Cover with shade cloth and plastic to eliminate excess moisture entering the graft union.

Once trees are grafted, it is imperative that a warm humid microclimate be maintained about the scion until it becomes established. Humidity can be maintained by placing newly grafted trees in a protected area or structure, in shade.

In an open area where wind is not a problem, a small plastic bag plus a small brown paper bag may be placed over the scion. Where bags have been used it is necessary to check the graft regularly, and remove the covers as soon as strong scion growth becomes obvious.

Remove suckers from the stock regularly as these multiply and grow rapidly once the top of the rootstock has been removed. They will compete with the scion and may dominate it.

Once the scion produces leaves, the new growth must be supported with a stake, as it is very susceptible to wind damage. Following grafting, it is important that the rootstocks are not allowed to wilt. Maintain constant soil moisture, but do not over-water.

Any stress increases the percentage of losses. At no stage let plants go more than two days without watering. Successful grafts start to grow after three weeks. Some grafts stay dormant for a long time before growing. While the scion stays green, however, the graft is still alive.