Persimmon information kit

Reprint – information current in 2005

REPRINT INFORMATION – PLEASE READ!

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

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 We advise readers to take particular note of the areas most likely to be out-of-date and so requiring further research: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- Financial information—costs and returns listed in this publication are out of date.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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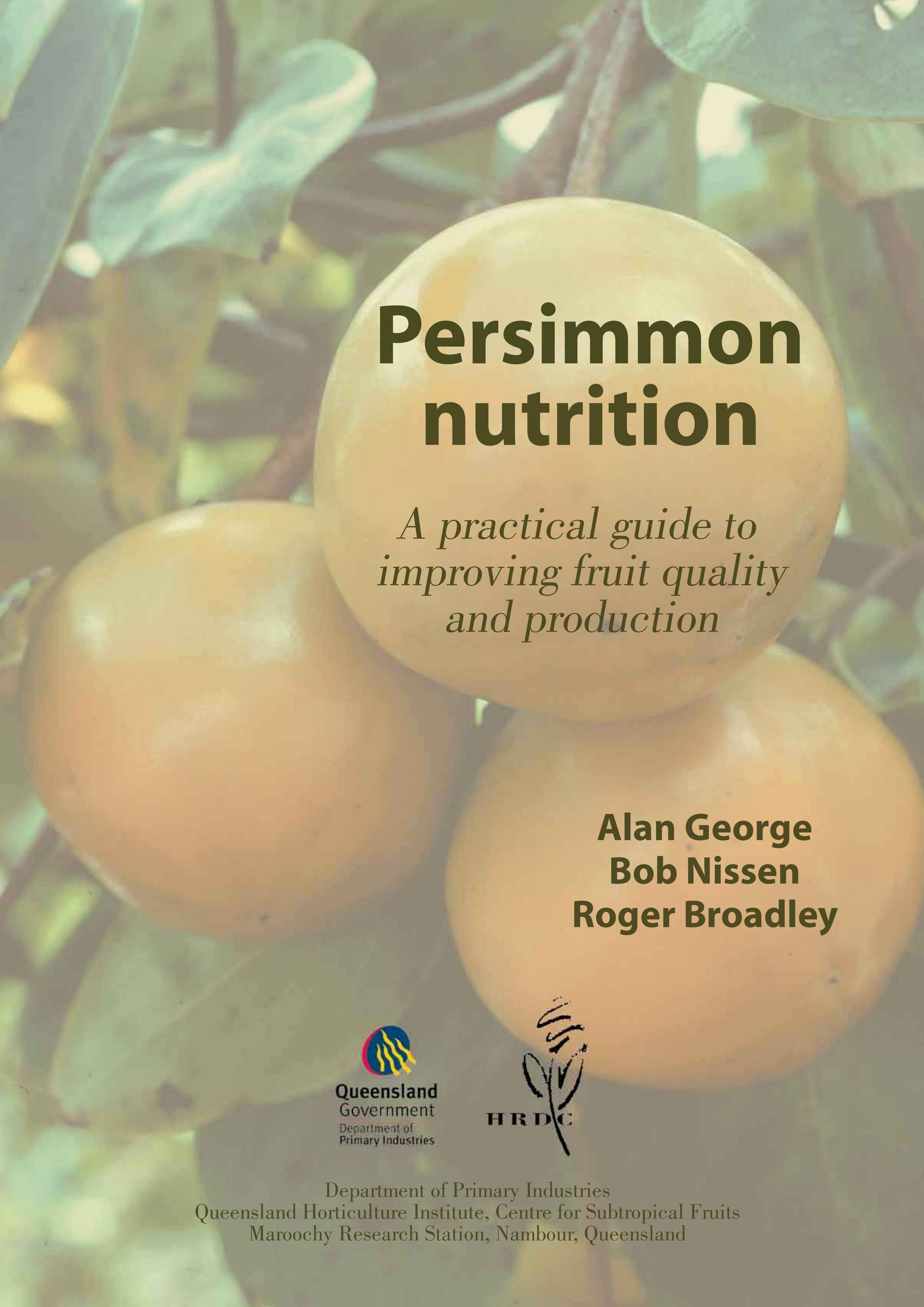

Persimmon nutrition

A practical guide to improving fruit quality and production

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Introduction

The Australian persimmon industry extends from semi-tropical far north Queensland to the cool temperate zones of Victoria, South Australia and Western Australia. Fruit from the warmer regions mature four months earlier, giving a whole-of-industry harvest spread from February to June. Most of the Australian industry is based on the non-astringent cv. Fuyu (Figure 1).

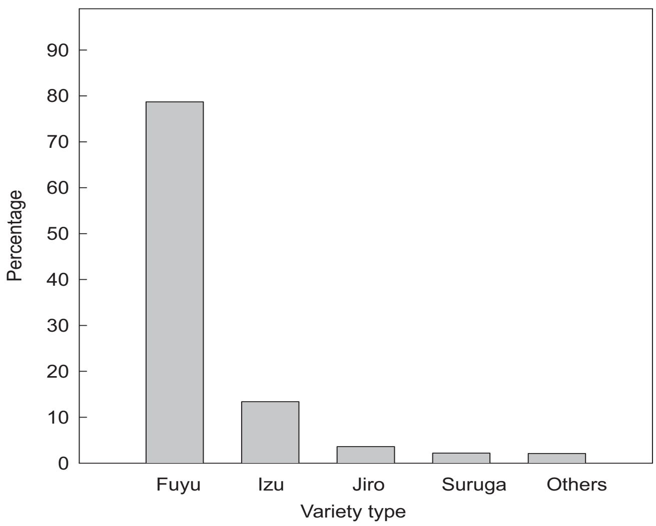


Figure 1. *Persimmon varieties planted in Australia*

There is a wide range of yield and fruit size grades between regions and within regions. Temperature, salinity, poor pollination, nutrition, and training and management systems all contribute to lower yields of marketable fruit and smaller size grades. Smaller fruit were found in orchards without polliniser trees, but there were some exceptions and these need more detailed study. Fruit size in some regions of Australia has been badly affected by soil salinity.

The tree training systems used in Australia are free-standing vase, trellised palmette, Tatura and Ruakura Y. Training systems which use a trellis system produce higher yields of marketable fruit through increased planting density and improved light interception. These more stable trees produce fruit with fewer blemishes, a major quality defect.

In 1999 there were an estimated 303 744 persimmon trees in Australia, based on tree numbers collected from survey data and market throughput. Australian production is estimated to be 2123 tonnes per year with an average yield of 15.8 t/ha. The average tree age was 5.7 years, the average area planted to persimmons per farm was 2 ha and the average block size was 436 trees. The average planting distance was 4.5 m between rows and 3.2 m between trees within rows.

Survey results also showed that about 65% of the present plantings were young trees less than six years old (Figure 2).

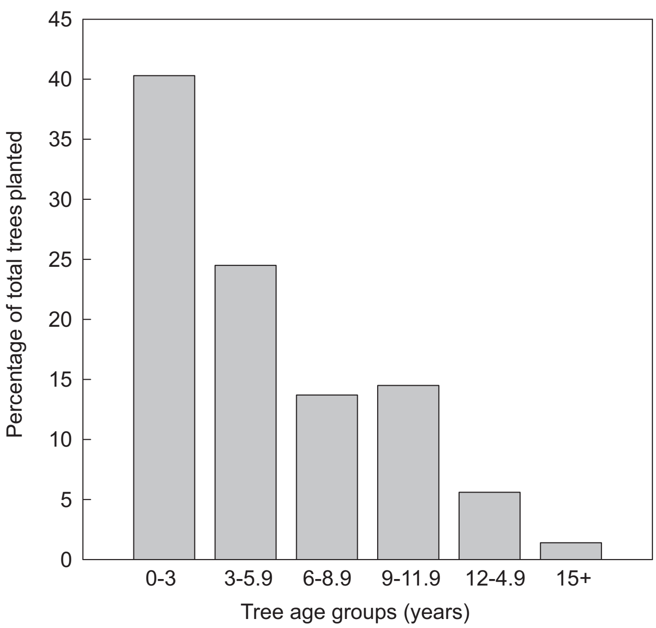


Figure 2. *Plantings, by tree age, in Australia*

Nutritional *studies*

Poor fruit quality, namely small fruit size and poor post-harvest storage life, have been identified as major problems for the Australian non-astringent persimmon industry. Few or no studies have been conducted to evaluate the effects of nutritional practices on fruit size or other quality variables such as colour or storage life.

In 1997, the Australian Persimmon Growers Association and Horticulture Australia (formerly the Horticultural Research and Development Corporation) jointly funded a research project titled *Nutritional management of non-astringent persimmon*. This project was conducted by researchers from the Queensland Horticulture Institute at the Department of Primary Industries' Maroochy Research Station, Nambour, Queensland.

The purpose of this project was to improve the yield and overall fruit quality of non-astringent persimmon through optimising tree nutrition. Studies were conducted to evaluate the following aspects:

- Variable rates and timing of nitrogen and potassium on yield, fruit quality and post-harvest storage life of non-astringent persimmon on a range of soil types in subtropical Australia.
- The beneficial effects, if any, from foliar applications of minor elements during flowering and pre-harvest, two critical stages of tree growth.

Current nutritional practices in high yielding orchards were also surveyed.

The results of these findings have been incorporated into this user-friendly, nutritional management booklet which incorporates past experience, the results of the project and the best available overseas (especially Japanese) information on persimmon nutrition.

Nitrogen (N)

Role

Nitrogen is one of the most important nutrients. It controls growth and fruiting in plants. It is a constituent of plant proteins, enzymes and cell membranes, and is also a part of 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 in most leaves. Trees with adequate nitrogen have dark green leaves and are very 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 3 and 4). Yield is highest when low rates of nitrogen are applied at budbreak, followed by higher rates in January (see Table 5 on page 21 in *Fertiliser program*). This fertiliser timing coincides with the major uptake period for nitrogen found in Japan.

Fruit quality

Excessive nitrogen can also reduce both fruit sugar concentrations and storage life by 30 to 40% (Figure 5). The critical leaf nitrogen concentration one month before harvest appears to be 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 6).

Storage life

Increasing rates of nitrogen can decrease storage life, particularly for fruit grown on low calcareous, highly leached, sandy, coastal soil types, e.g. podzolics (Figure 7). At leaf nitrogen concentrations greater than 2.2%, storage life is greatly reduced (Figure 8).

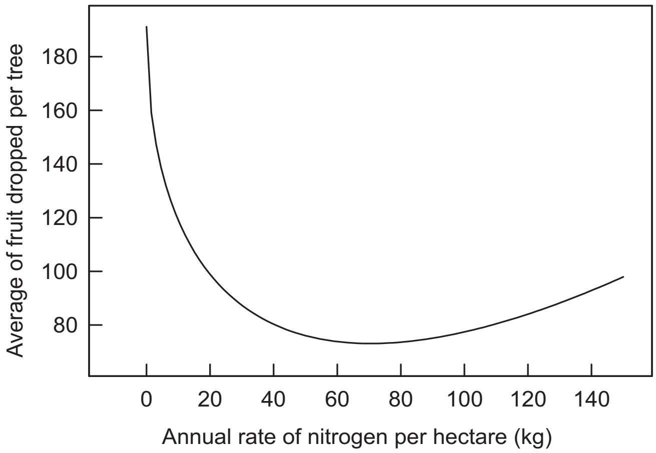


Figure 3. *Effects of soil-applied nitrogen on average number of fruit dropped per tree*

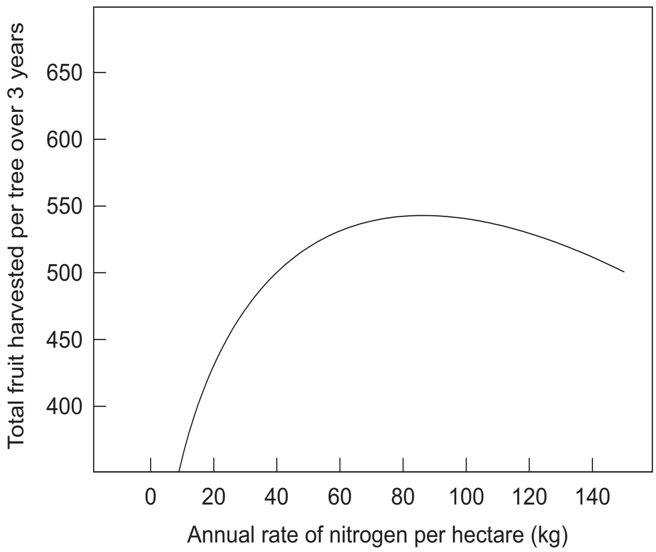


Figure 4. *Effects of soil-applied nitrogen on total number of fruit harvested per tree over three years*

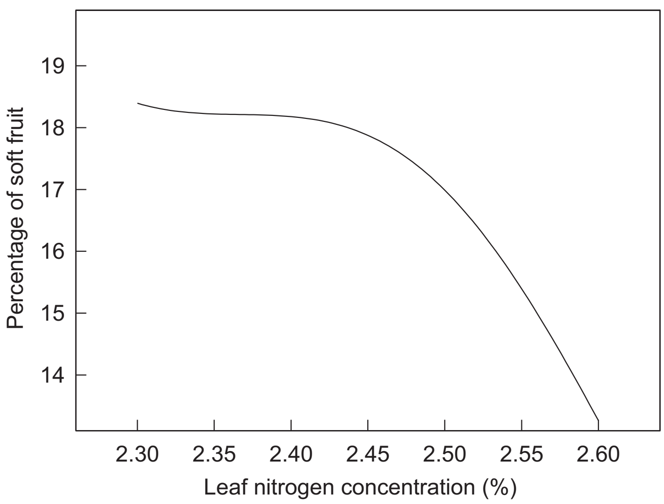


Figure 5. *Relationship between leaf nitrogen concentration one month before harvest and fruit sugar concentration at harvest.*

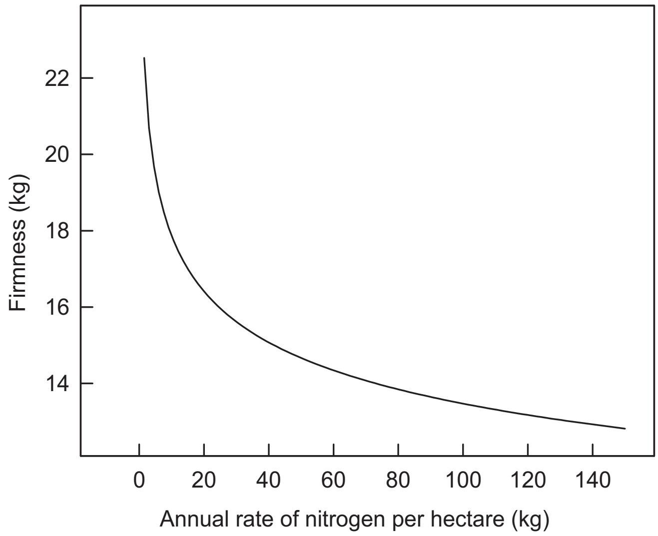


Figure 6. *Effects of soil-applied nitrogen on fruit firmness*

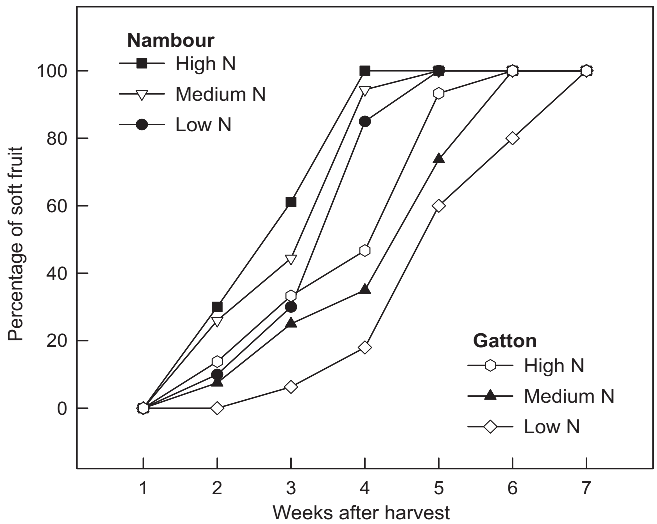


Figure 7. *Effects of soil-applied nitrogen on storage life at 21°C of non-astringent persimmon cv. Fuyu at Nambour and Gatton, Queensland in 2000. Gatton has highly calcareous soils compared with Nambour, which has highly leached podzolics.*

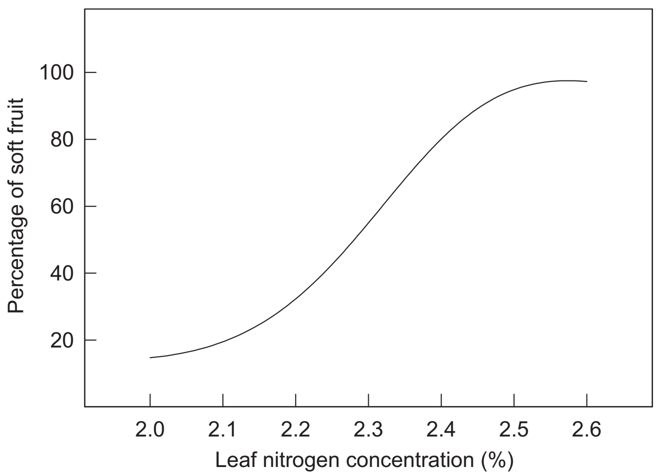


Figure 8. *Relationship between leaf nitrogen concentration one month before harvest and percentage soft fruit stored at 21°C*

Optimum rate of nitrogen application

The optimum annual rate of nitrogen application is about 80 to 90 kg/ha. Higher rates give 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 compromise needs to be reached between achieving larger fruit size at the expense of fruit quality.

For 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%. When 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 be greater than 1.5 one month before harvest.

Phosphorus (P)

Role

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. Oldest leaves may develop a mottled appearance before early leaf fall. New leaves are narrow. High levels of phosphorus may cause zinc and copper deficiencies. Phosphorus deficiency, however, is rarely seen in persimmons.

Optimum rate of phosphorus

Based on crop removal rates for a 20 tonne crop of about 5 kg of phosphorus per hectare, the phosphorus requirements for persimmon are very low (see *Fertiliser program*). Phosphorus uptake by the plant is slow, probably less than half for nitrogen and potassium. It quickly reverts to insoluble forms, particularly in acid soils. As a guide only, and allowing for leaching losses and fixation, about 15 kg of elemental phosphorus should be applied per hectare.

Overfertilising with phosphorus is very common for Australian soils, 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)

Role

Potassium plays an important role in photosynthesis and carbohydrate production processes, 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 a high potassium content while sandy soils have a low potassium content.

Symptoms

Deficiency symptoms first appear on recently matured leaves. A marginal leaf scorch on the older leaves is preceded by interveinal chlorosis. A deficiency is 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 of potassium per hectare per year and thereafter much more slowly (Figures 9 and 10). At greater than 120 kg of potassium per hectare per year there is little additional response to potassium.

Fruit quality

Effects of potassium on fruit quality are variable, with sugar concentrations and fruit firmness increased in some seasons only (Figure 11).

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 due to displaced calcium uptake particularly on low calcareous soil types (Figure 12). 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 one month before harvest (Figure 13).

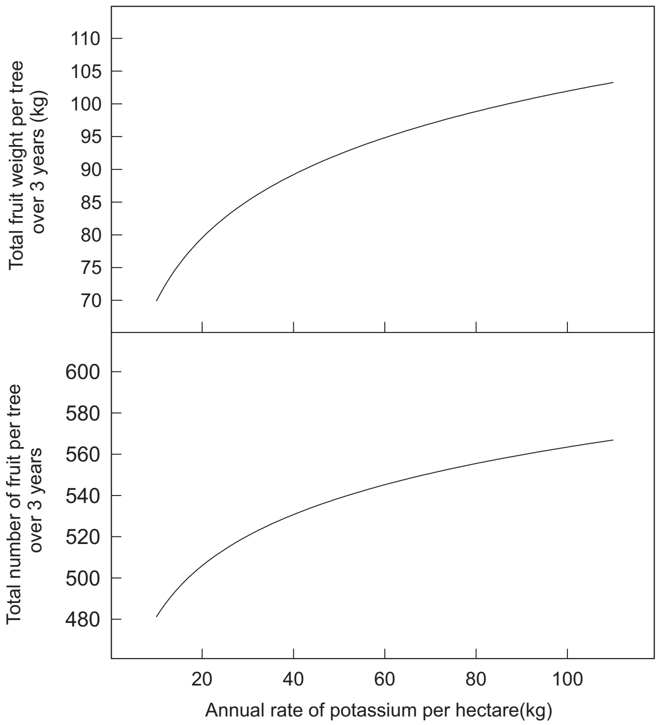


Figure 9. *Effects of soil-applied potassium on total yield per tree over three years*

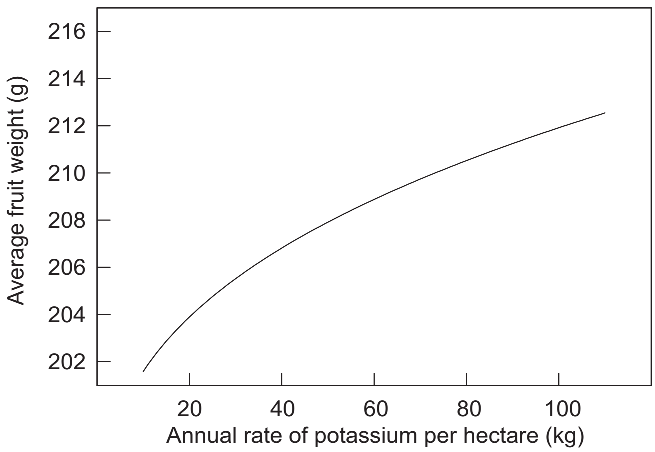


Figure 10. *Effects of soil-applied potassium on average fruit weight*

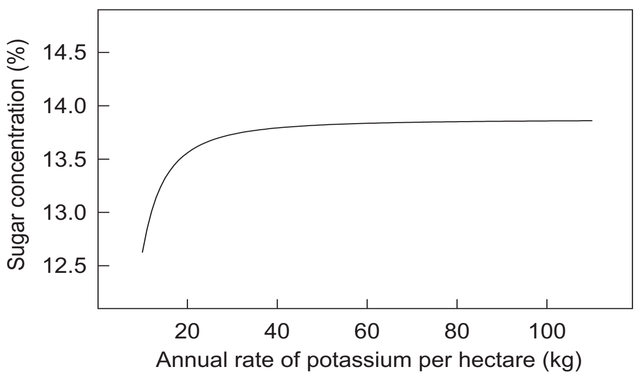


Figure 11. *Effects of soil-applied potassium on sugar concentrations at Nambour, Queensland*

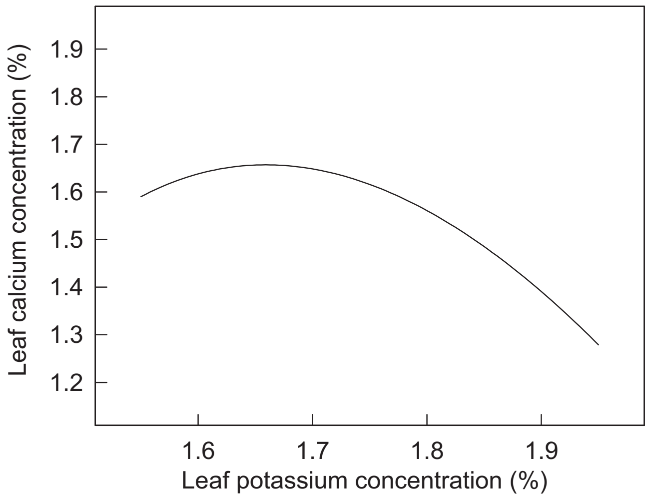


Figure 12. *Relationship between leaf potassium and calcium concentration one month before harvest*

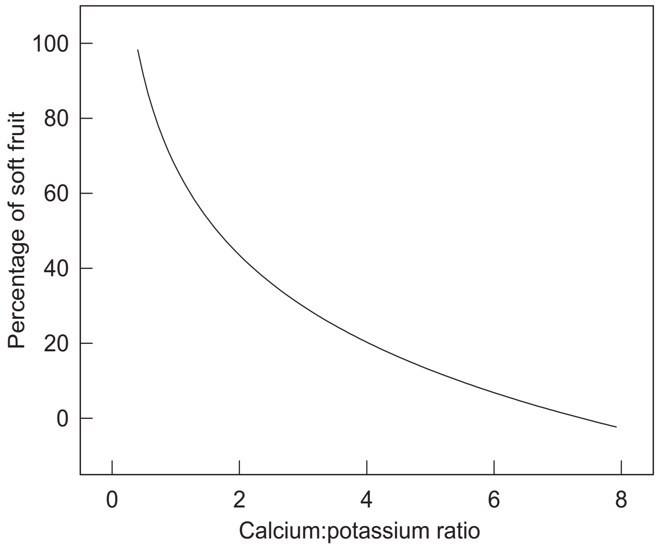


Figure 13. *Relationship between fruit softening two weeks after storage at 21°C and leaf calcium:potassium ratio*

Optimum rate of potassium application

The optimum application appears to be about 100 to 120 kg of potassium per hectare. 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 range one month before harvest is between 1.5 and 2.0% to achieve maximum productivity and fruit quality. The leaf calcium:potassium ratio should be greater than 1.5.

Calcium (Ca)

Role

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 ions) 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 persimmon in subtropical Australia. These problems may be due to inadequate mineral nutrition of developing fruitlets caused by poor uptake of nutrient 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 14). Growers are also using a wide range of foliar calcium sprays to improve the quality of their persimmon.

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 (see Foliar fertilising).

Rates and timing of potassium and nitrogen fertilisers

High rates of potassium applied during budbreak 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 15). 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 100 mg/kg boron (Figure 16).

Effects of environment on calcium uptake

Low soil and air temperatures during fruit set adversely affect calcium uptake (Figure 17). There is a strong correlation between mean minimum air temperature preceding fruit set and leaf calcium concentration at fruit set. A mean minimum air temperature of 10°C and below appears to be the critical temperatures when calcium uptake is markedly affected.

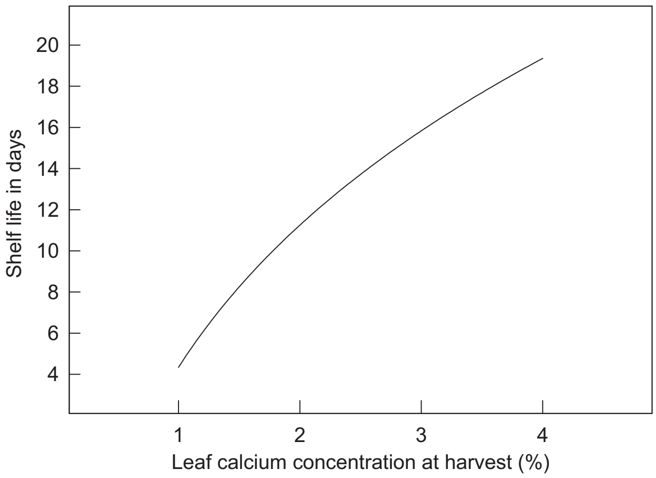


Figure 14. *Relationship between leaf calcium concentration and shelf life at ambient temperature for selected orchards*

Foliar application of calcium

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 an 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.

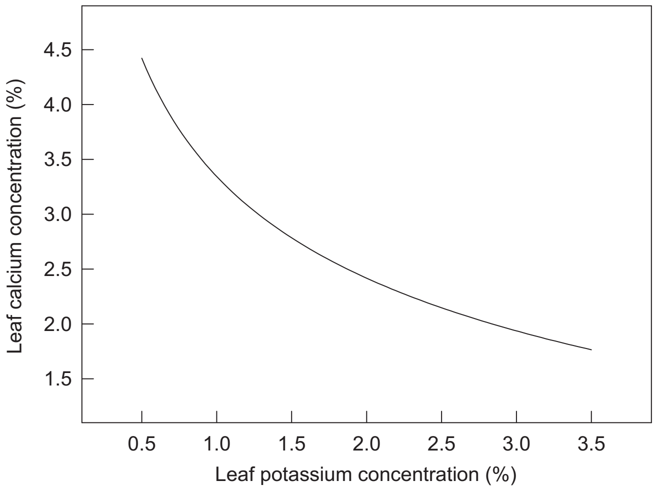


Figure 15. *Relationship between leaf potassium and leaf calcium from surveys conducted from 1995–2000 in subtropical Australia*

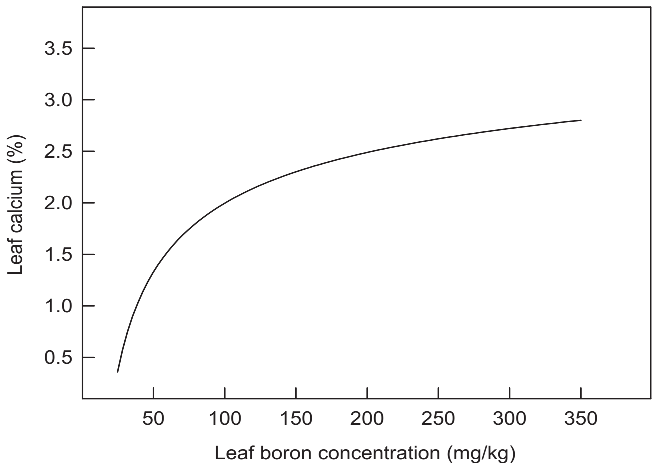


Figure 16. *Relationship between leaf boron concentration and leaf calcium concentration one month before harvest for selected persimmon orchards*

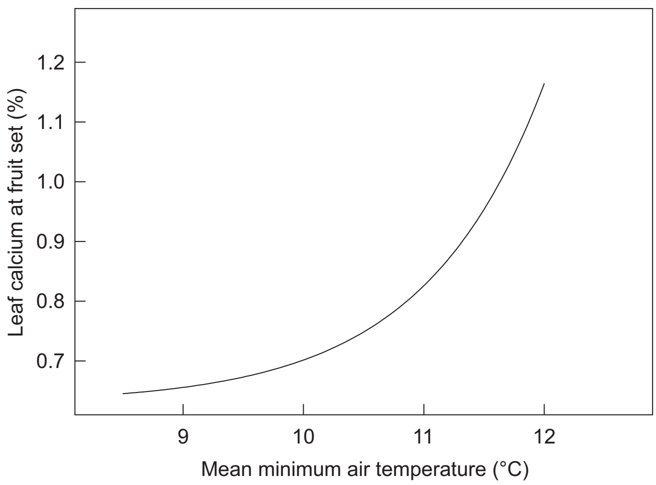


Figure 17. *Relationship between leaf calcium at fruit set and mean minimum air temperature in the six weeks from budbreak to fruit set*

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 18). 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.

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, the leaf calcium concentration at fruit set should be greater than 0.8% and, by January, greater than 2.0% (Figure 18).

Interactions

The uptake of calcium by the persimmon tree is complex, with many interactions between the tree, soil and weather affecting uptake (Figure 19). Besides modifying the soil nutrient levels of calcium, potassium and boron it may also be necessary to alter other practices. Some of these are 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 bee hives in the orchard;
- control growth through summer pruning.

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

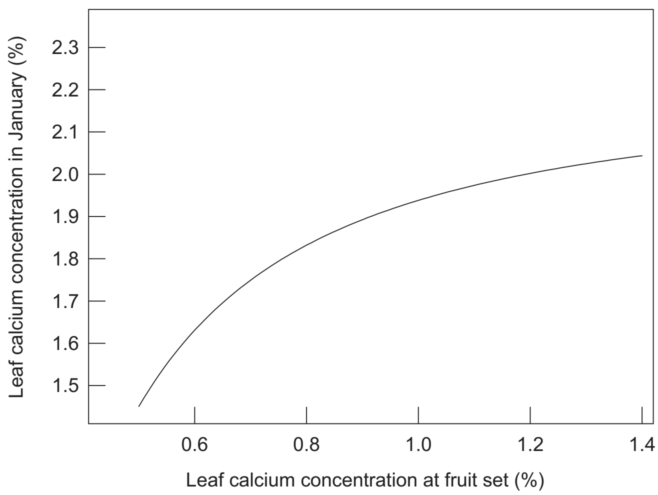


Figure 18. *Relationship between leaf calcium concentration at fruit set and in January, at the end of Stage 1 fruit growth*

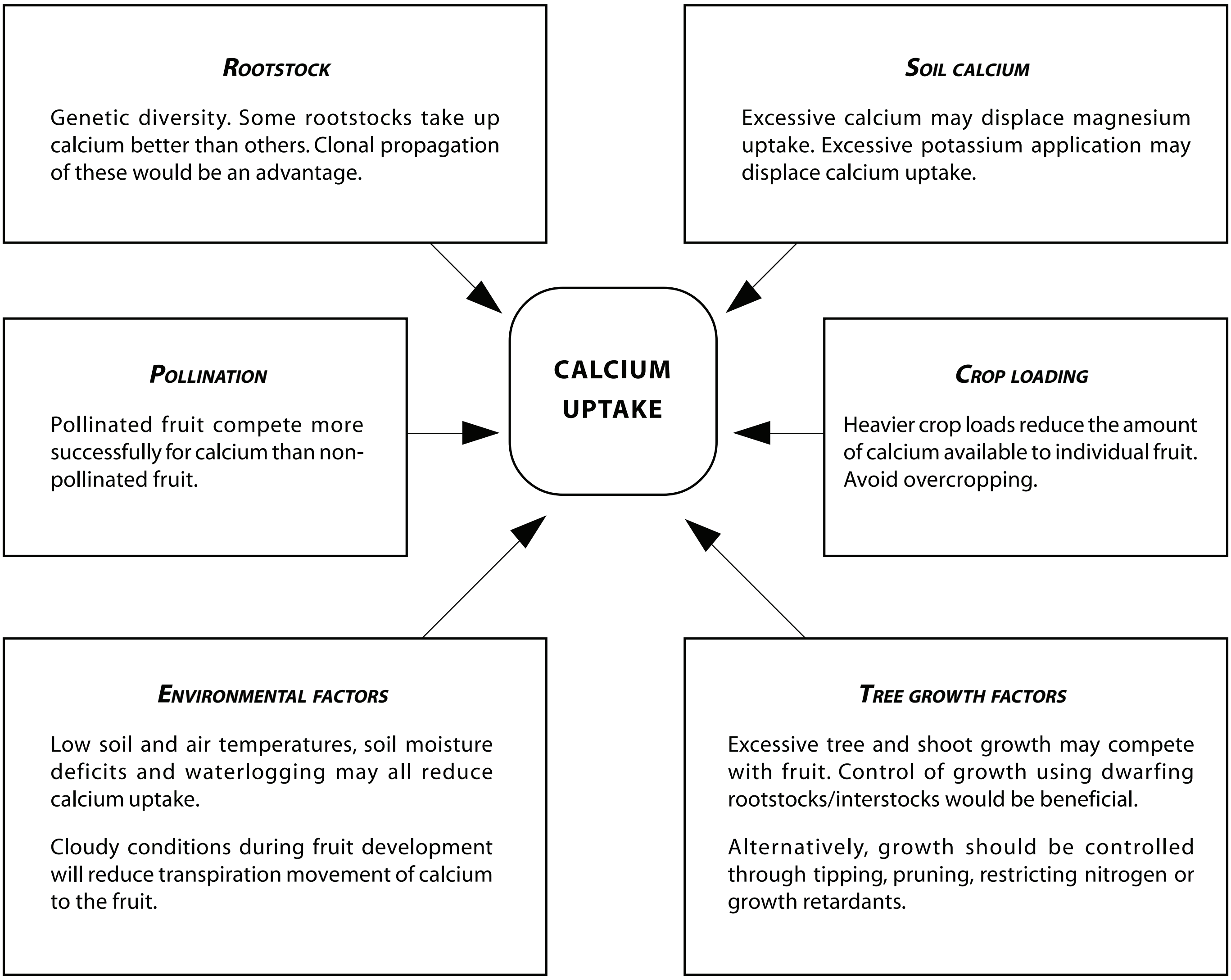


Figure 19. *Inter-relationships between soil, tree and weather factors that affect calcium uptake*

Magnesium (Mg)

Role

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

Symptoms

Initial deficiency symptoms consist of interveinal chlorosis of the basal leaves on a bearing shoot and 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/early autumn and are more pronounced during dry summers. Applying heavy rates of potassium and calcium fertilisers can induce a magnesium deficiency. Leaf magnesium concentrations from January through to harvest are negatively correlated with leaf potassium concentrations (Figure 20).

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 of elemental magnesium per hectare. 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 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 less than 0.15% are deficient. The cv. Jiro is more susceptible to magnesium deficiency than Fuyu.

Manganese (Mn)

Role

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

Symptoms of deficiency

This disorder 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 colouration. Leaf manganese concentrations less than 30 mg/kg are deficient. This disorder is rarely seen in Australia.

Control of deficiency

A foliar application of manganese sulphate would control a deficiency. Regular use of some protectant fungicides provides this micronutrient. Mancozeb fungicide applications can lead to an artificially high leaf analysis reading because the elemental manganese 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 concentration in the leaf and fruit and may be caused by excessive absorption of manganese (see *Review of persimmon nutrition literature*). Some varieties such as Matsumotowase Fuyu are more susceptible than others.

Control of toxicity

This disorder 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 severity.

Optimum leaf and soil manganese concentrations

Leaf manganese concentrations are reduced as leaf calcium concentrations increase (Figure 21). In Australia, the DTPA extraction method is commonly 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 compared with 2.5 mg/kg in normal orchards.

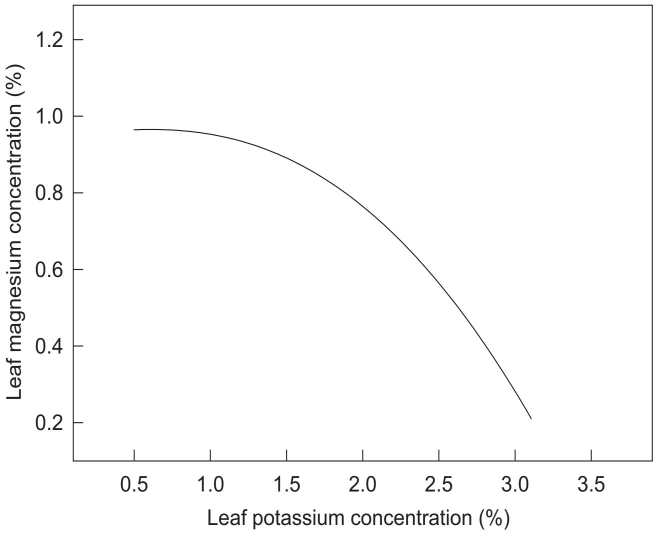


Figure 20. *Relationship between leaf potassium and leaf magnesium concentrations one month before harvest*

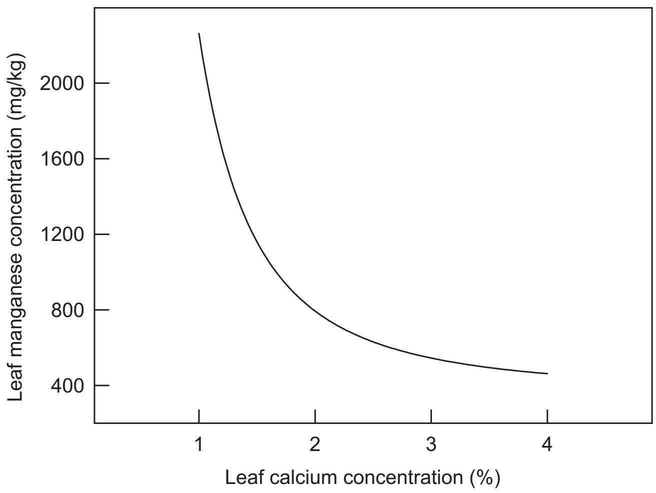


Figure 21. *Relationship between leaf calcium concentration and leaf manganese concentration one month before harvest for selected persimmon orchards*

Minor nutrients

Zinc (Zn)

Role

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

Symptoms

Deficiency symptoms appear in young leaves and can restrict leaf size or stem length or both. It is described as 1ittle leaf or 'rosetting'. A distinct interveinal yellowing of the leaf is commonly seen. Heavy root-knot nematode infestation can induce spring rosetting similar to zinc deficiency.

Other nutrient interactions

Overliming can contribute to zinc deficiency.

Copper (Cu)

Role

Copper is important in respiration and chlorophyll formation.

Symptoms

Deficiency symptoms 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)

Role

Boron is primarily concerned with both the uptake and efficient use of calcium in 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.

Symptoms

In 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.

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

Other nutrient interactions

The uptake of boron is often associated with the uptake of calcium (see 'Calcium' on page 6).

Iron (Fe)

Role

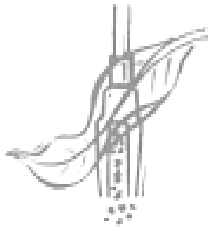
Iron is essential for chlorophyll formation, although it is not a constituent of chlorophyll. The amount of chlorophyll is apparently related to the readily soluble iron content in the plant. This element is the most immobile of all elements in the plant.

Symptoms

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

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

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



How to take leaf and soil samples

Leaf and soil nutrient analyses are used to monitor the nutritional status of persimmon trees and to alter fertiliser rates and timing. By the time trees show obvious deficiency symptoms, both yield and fruit quality may have been severely affected.

Leaf analyses are more reliable indicators of the nutritional status of persimmon trees because they show what nutrients have been taken up by the tree.

Soil analyses are mainly used to determine if there are major soil problems such as salinity or high acidity and also to help in the interpretation and causes of abnormal leaf analyses results.

To gain maximum benefit from soil and leaf analyses, the correct sampling technique must be followed otherwise the analytical results may contain significant errors and will not represent the soil and leaf status of the orchard.

Leaf sampling

Timely leaf analyses offer a 'snapshot' view of the immediate nutrient status of the orchard, but cannot show what nutrient deficiencies are likely in the future. They must be used 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 concentration at the time of sampling and whether the plant has an adequate supply.

Leaf sampling must meet precise specifications regarding:

- timing;
- position and type of leaf sampled;
- whether the sample is representative of the trees.

When to sample

Research shows that leaf and soil sampling in persimmons should be undertaken **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 if the trees have the optimum level of nutrition. It also allows deficiencies to be corrected through fertilising during the current season's growth.

Equipment

A sharp pen-knife (or finger nails), a clean paper bag (plastic bags are unsuitable) and clean hands are required for sampling.

Do not sample leaves from trees in unusual spots or conditions. 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 climatic conditions, such as floods, drought, extreme cold, heat waves or immediately after spraying fungicides, such as mancozeb or pesticides.

Taking a sample

There are two options. For free-standing trees, sample four leaves from each of 20 to 25 trees. For hedgerows (palmette, Tatura and Ruakura Y), sample two leaves per tree, one from each side of 50 trees.

Take the first fully mature leaves, usually the 5th, 6th or 7th leaf back from the growing point. Sample only non-fruiting shoots as fruiting can affect leaf nutrient concentrations. See Figures 22 (a) and (b).

Where there are differences or variations in soil types, tree age and varieties within the orchard, take a separate sample from each block.

Preparing the leaf sample

Keep the sample cool by storing it in an esky. Plant samples should be sun-dried or air-dried before dispatch as plant material may start to decompose if sent long distances. Be sure to keep them away from dust and fertiliser. Wet samples should be air-dried before packing to prevent mould.

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.

Figure 22 (a). *Select a shoot from each side of the tree*

Figure 22 (b). *Sample the first fully mature leaf (usually the 5th, 6th or 7th leaf) from the growing tip*

Soil sampling

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 through the level of organic carbon.

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

Do not sample unusual spots 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, i.e. at fruit set. Taking the soil sample at this time will allow for a better interpretation of the leaf nutrient analyses results 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. If lime, dolomite, gypsum or other fertilisers have been applied to the sampled area, gently scrape away a thin layer of soil because this may affect the results and give a false reading. Dig a hole, then take a thin slice down the side of the hole or alternatively drill the auger to the desired depth. See Figures 23 (a), (b), (c) and (d).

Sample depth

Sampling to a consistent depth is important. This should be approximately the depth of the main root zone. Persimmons should be sampled to at least 30 cm deep or alternatively two samples could be taken, the first at 0 to 15 cm and then 15 to 30 cm.

Sampling the orchard

Divide the orchard into reasonably uniform areas. Do not mix soil from obviously different areas. Sample about 15 different sites from each uniform area. Select your sampling sites from under the tree canopy, within the wetted area of the sprinkler and no closer than 30 cm from the tree butt.

Put all 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

The sub-sample must represent the bulk sample. Mix the soil in the bucket and then remove about a cup full. Do this by taking many pinches from the bucket, stopping occasionally to mix the remaining soil. Spread the cup full 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. The sample should be sent to the laboratory immediately so that it can arrive within two days to reduce chemical change. Alternatively, it should be stored in the refrigerator for posting early in the week.

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 persimmon orchards. This includes soil pH, electrical conductivity, phosphorus and the exchangeable cations which include calcium, magnesium, potassium, sodium and aluminium.

Figure 23 (a). *Select a sampling site under the tree canopy within the wet area from the sprinkler*

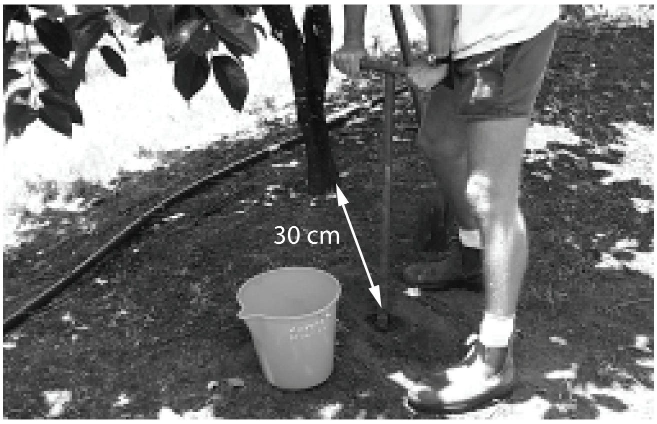
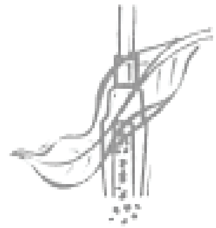


Figure 23 (b). *Take the sample at least 30 cm from the tree butt*

Figure 23 (c). *Avoid sampling residual fertiliser. Scrape a thin layer of soil*

Figure 23 (d). *Sample at least 30 cm deep or take two samples at 0 – 15 cm and at 15 – 30 cm. Place samples in separate, well-labelled containers*



Interpreting *results of* soil and leaf analyses

Leaf and soil analyses are used to monitor the nutritional status of persimmon trees. Based on the interpretation of these analyses, fertiliser rates and timing can be adjusted accordingly so the tree maintains the optimum plane of nutrition. Leaf analysis shows the nutrient status of the plant while a soil analysis shows salinity, degree of acidity and balance of the positively charged cations—calcium, magnesium and potassium. When nutrient analyses are used together with agronomic and management information, and tree growth and yield, the orchard fertiliser program can be modified to suit the range in soil types and micro-climates.

Nutrient concentrations will vary from one year to the next and if sound management practices are followed values should be within the adequate range. Sampling and analytical errors, tree age, crop load, pruning levels, variety and seasonal conditions will influence such variation.

Leaf analysis data should be evaluated in conjunction with soil analysis data, current fertiliser strategy and observed plant growth and yield. If leaf levels are at the low end of the adequate range, it may reflect a low tree nutrient status. If leaf levels are at the high end of the range, this may indicate a high tree nutrient status.

Leaf analysis interpretation

The leaf nutrient standards have been revised and a new, more accurate range of standards set at both fruit set and one month before harvest (Table 2). The optimal leaf nutrient bands for bearing mature persimmon trees are shown in Figure 24.

Setting standards at both fruit set and before harvest allows closer monitoring of the optimum nutrition levels during the growing season. In addition fertiliser use can be corrected before the major uptake periods for nitrogen, potassium and magnesium. The rationale for the changes in leaf nutrient standards are shown below.

Table 2. *New Australian leaf nutrient standards for mature (more than five years old) non-astringent persimmon*

Nutrient	Standards at fruit set	Standards one month before harvest[1]
Nitrogen (%)	2.4 – 2.9 less than 2.0 deficient greater than 3.0 excessive	1.8 – 2.2 greater than 2.5 reduced 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

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

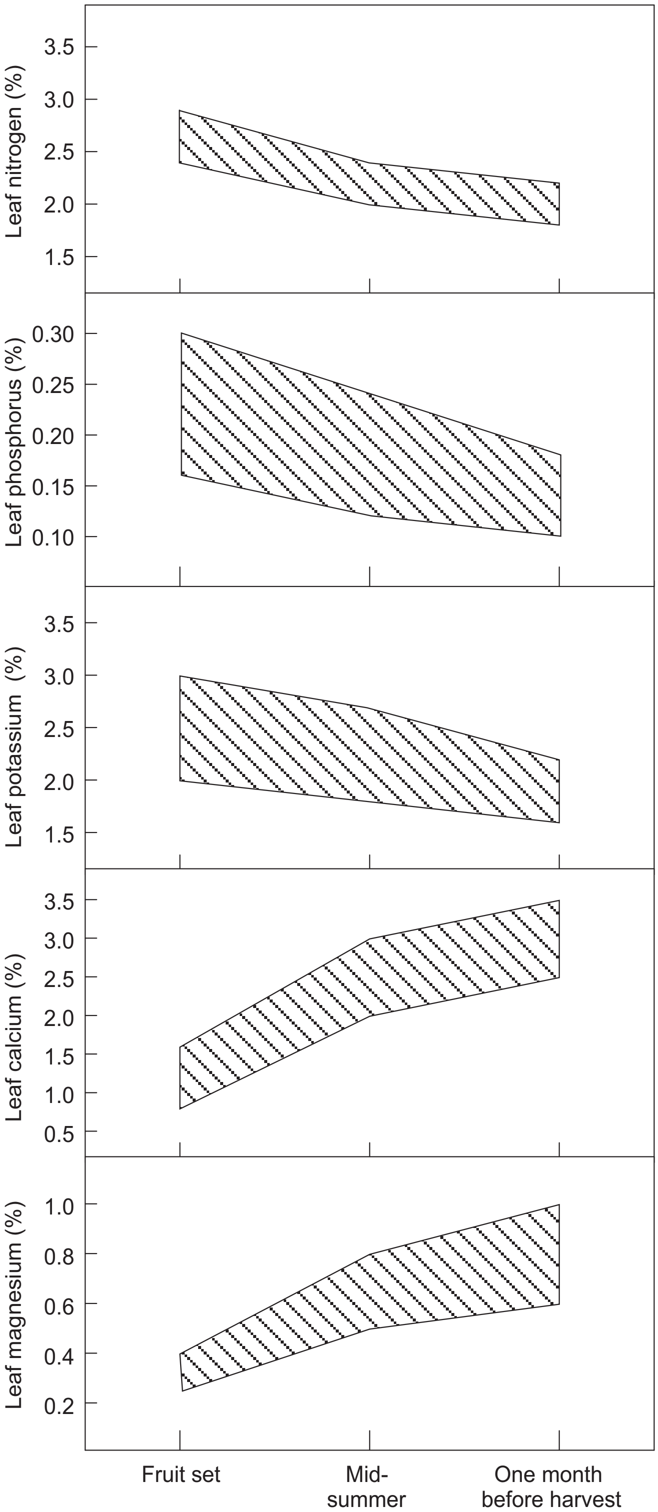


Figure 24. *The optimum leaf nutrient bands (shaded area) for bearing mature persimmon trees*

Nitrogen (N)

Leaf nitrogen levels will vary from season to season and be influenced by seasonal conditions (particularly rainfall), tree age, crop load and pruning levels. Deficiency may be due to inadequate nitrogen fertilisation, ineffective nitrogen application or root damage. Other reasons for low leaf nitrogen levels should also be carefully examined. Check the amount and timing of nitrogen applications.

Based on the findings of several grower surveys conducted in Australia and Japan, leaf nitrogen concentrations **greater than 2.5% one month before harvest were associated with:**

- increased severity of calyx cavity;
- reduced fruit sugar levels;
- reduced shelf and storage life.

In contrast, leaf concentrations of less than 2.0% were associated with reduced yield and fruit size. A compromise between obtaining larger fruit size grades at the expense of reduced fruit quality must be reached. Since the Australian industry increasingly relies on export markets, where good post-harvest life is essential, the revised leaf nitrogen concentrations have been set at relatively conservative levels of between 1.8 and 2.2% one month before harvest.

Phosphorus (P)

For most Australian soils, excessive phosphorus application may be problem, particularly where mixed fertilisers are used regularly. Less than sufficient phosphorus due to inadequate phosphorus fertilisation is highly unlikely. Phosphorus can be fixed in acid soils with high iron or aluminium content. Test your soil and follow the soil test recommendation. Check soil pH and adjust to proper pH by liming. Leaf phosphorus concentrations should be maintained between 0.10 and 0.18% one month before harvest.

Potassium (K)

Less than sufficient potassium may be due to inadequate potassium fertilisation or excessive leaching, particularly for sandy soils. Test your soil and follow the soil test recommendations. Potassium competes with magnesium and calcium for uptake in persimmon trees and excessive levels of one may cause deficiencies of the other. Check timing of potassium applications.

Accurate leaf potassium concentrations are difficult to set because of the draw-down of leaf potassium during the later stages of fruit development. The depletion in leaf potassium is highly dependent on the crop load. A suitable leaf potassium range one month before harvest for an average crop load of 20 t/ha appears to be between 1.8 and 2.0%.

Sulphur (S)

Many fungicides and fertilisers contain sulphur and they normally provide sufficient quantities to satisfy the small amount required.

Calcium (Ca)

Most persimmon orchards surveyed had low leaf calcium concentrations. The new revised standards are now set at 2.5 to 3.5%, significantly higher than the previously set standards. To maintain the balance between calcium and nitrogen and potassium within the tree, the leaf calcium:nitrogen and the leaf calcium:potassium ratios should be maintained at greater than 1.5.

Less than sufficient calcium may be associated with low soil pH, low calcium or a cation imbalance. Test your soil and lime to bring the soil pH to 6.5 (see *Liming*). On lighter textured soils, liming will increase pH rapidly but for heavier soils with high buffering capacity this may take several years. Where soil pH is adequate, gypsum will increase calcium concentrations faster than lime. Trees with low calcium levels should be examined for other symptoms.

Magnesium (Mg)

Less than sufficient magnesium may be due to low soil pH, high soil calcium and/or potassium and/or a low soil test magnesium level. Test your soil and follow the lime recommendation using dolomite or limestone to correct soil acidity or use magnesium oxide. The new revised standards are now set at 0.6 to 1.0%, one month before harvest.

Sodium (Na) and chloride (Cl)

Persimmon is sensitive to high concentrations of salt (sodium chloride). Although an excess of either sodium or chloride can be toxic, high leaf chloride is more common as sodium is less likely to be transferred to the leaves of fruit trees. Because yield and fruit quality were adversely affected at leaf chloride concentrations greater than 0.8%, the new leaf standard has been set at a conservative concentration of 0.4% (see *Salinity*).

One way of reducing salinity in the field may include altering the type and frequency of irrigation. In Israel, pulse irrigation is used to alleviate some salinity problems. In Israel it is claimed that *Diospyros virginiana* is more salt-tolerant than *Diospyros kaki*, however we have found that the cv. Fuyu is incompatible on the strain of *D. virginiana* originally tested in Australia in the 1970s. Selection of salt-tolerant strains of rootstocks is urgently needed.

The muriate or chloride form of potassium (KCl) should be avoided.

Copper (Cu)

Sprays of copper oxychloride at 4 to 6 g/L during dormancy should supply sufficient copper for deficient trees. Alternatively, use soil-applied copper. Application rates vary between 50 and 150 g per tree, depending on tree density. It may take up to three years to correct the deficiency.

Zinc (Zn)

Zinc deficiency can occur on light soils. Heavy liming (high pH), excessive phosphorus and high rates of nitrogen contribute to zinc deficiency. Symptoms sometimes appear in spring and disappear with increasing soil and air temperature. Heavy root-knot nematode pressure can induce symptoms resembling zinc deficiency. If levels are deficient, applications of chelated zinc may be beneficial.

Manganese (Mn)

Although higher leaf manganese concentrations in excess of 2000 mg/kg are not always associated with green blotch disorder, we would recommend that leaf manganese concentrations be maintained as low as possible and ideally below 500 mg/kg.

High levels may also reflect the use of mancozeb sprays or sprays containing manganese. Most of the manganese will be on the leaf surface. Mancozeb sprays used for fungal disease control will often supply sufficient manganese to correct a mild deficiency. Otherwise, apply 100 g/100 L of manganese sulphate after budbreak.

Iron (Fe)

Heavy liming may cause iron deficiency, but the condition is usually only mild and temporary in tree crops because of their extensive root system. If both iron and aluminium are high (greater than 300 mg/kg), suspect soil or dust contamination on the leaf surface.

Boron (B)

Leaf calcium concentrations were associated with higher leaf boron concentrations up to a plateau of 100 mg/kg. For this reason, the new leaf boron standard has been set at about 100 mg/kg. At leaf boron concentrations greater than 150 mg/kg boron may start to become toxic, so this concentration should be set as the maximum permissible. Continue to monitor with follow-up leaf analysis.

To correct for deficiencies apply 1 to 2 g of borax or 0.3 to 1.0 g of Solubor per square metre of soil surface beneath each tree. Toxicity may develop if rates are too high.

Molybdenum (Mo)

Adequate range not determined.

Aluminium (Al)

High aluminium concentrations in leaf tissue may be a sign of other tree problems and should be investigated. Aluminium does not normally enter the tree unless roots are damaged. If both iron and aluminium are high, soil and dust contamination may be suspected.

Soil analysis interpretation

Traditionally, soil sampling is recommended at a depth of 0 to 15 cm for most crops because nutrient concentrations and root density are highest in this layer. Most roots are distributed to 30 cm and some roots can maintain water and nutrient supply at a much greater depth. Most Australian persimmon soils are acid and have low available phosphorus levels, so lime and superphosphate are regularly applied.

Both these fertilisers move very slowly down the soil profile and a 0 to 5 cm soil analysis will often show adequate levels of available calcium when most of these nutrients are concentrated in the top 5 cm of soil (Table 3).

Nitrate, potassium and magnesium availability is much higher in the 0 to 15 cm depth. The 0 to 30 cm sample will give a more reliable indication of the availability of these nutrients because most persimmon roots are found at this depth. Splitting the sample into a 0 to 15 cm and 15 to 30 cm depth is the most reliable method. Take the samples at the same time as you conduct your leaf sampling at fruit set.

pH (1:5 water)

Soil pH needs to be maintained at 6.5 to 7.0 and soil calcium concentrations should be greater than 8 meq/100 g because of the importance of calcium to fruit quality. Where pH is measured by the calcium chloride method in 0.01M $CaCl_2$ the reading will be 0.6 to 0.8 lower than for the 1:5 water testing method.

Table 3. *New Australian soil nutrient standards for non-astringent persimmon*

Nutrient	Standards
pH (1:5 water)	6.5 – 7.0
pH (1:5 $CaCl_2$)	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 – 120mg/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.

Organic carbon (% w/w C)

A value of less than 2% organic carbon means your soil organic matter levels are low, while 5% suggests they are high. The use of cover crops, the addition of animal manures, mill mud and compost, mulching, mowing and minimum tillage will increase organic matter levels over time.

Nitrate nitrogen (mg/kg N)

Nitrate nitrogen is only a small fraction of the total nitrogen in the soil. If levels exceed 40 mg/kg, use crop replacement rates of 25 kg of nitrogen per hectare and continue to monitor soil and leaf nitrogen levels. If they are between 15 and 40 mg/kg, use replacement rates plus a modest allowance for leaching (about 50 kg/ha). If less than 15 mg/kg, apply full nitrogen rates of 90 kg/ha and continue to monitor soil and leaf nitrogen levels.

Phosphorus (mg/kg P, Colwell technique)

Persimmon trees have a low phosphorus requirement. Victorian research has shown that applying phosphorus before tree planting improves early growth. Further applications of phosphorus, however, may benefit an orchard cover crop and indirectly contribute to tree nutrition.

If soil phosphorus (Colwell) is less than 60 mg/kg apply phosphorus at a rate of 30 kg/ha. If phosphorus is between 60 and 100 mg/kg, apply phosphorus at replacement rates of 15 kg/ha. Too much phosphorus may cause a nutrient imbalance.

Potassium (meq/100 g K, or cmol+/kg K)

Potassium values greater than 0.5 meq/100 g are considered more than adequate. Fertiliser rates should be reviewed annually, preferably by soil testing. If soil potassium is more than 1.0 meq/100 g, check leaf potassium concentrations.

If these are adequate do not apply more potassium because fruit quality and storage life may be adversely affected.

High potassium rates will reduce soil calcium and magnesium uptake if magnesium fertiliser has not been applied.

In situations where high leaching of nutrients occurs, essentially in wet years, soil and leaf potassium and nitrogen levels should be monitored regularly. The recommended rate of 120 kg of elemental potassium allows for three to fourfold losses. Potassium should be 1 to 5% of the total exchangeable cations.

Calcium (meq/100 g Ca, or cmol+/kg Ca)

Calcium values normally range from 2 to 10 meq/100 g or about 65 to 80% of the total exchangeable cations. Soil calcium should be more than 8.0 meq/100 g.

Soil calcium levels can be increased by lime, dolomite or gypsum. The choice depends on pH, and calcium and magnesium values and ratio (see *Liming*). Gypsum is more soluble than lime and will move through the soil more rapidly than lime, but it will not increase pH.

Note: *Lime is highly insoluble and may take four to five years to have an effect.*

Magnesium (meq/100 g Mg, or cmol+/kg Mg)

Magnesium deficiency often develops in soils with low organic matter where the exchangeable magnesium in the rooting zone is less than 1.6 meq/100 g. Magnesium fertiliser applied at the rate of 100 to 200 kg/ha will correct the deficiency. Addition of soil organic matter to improve the retention of magnesium may also be beneficial. A deficiency can also arise where high potassium contents in soil reduce magnesium uptake during dry summers.

Magnesium values normally range from 1 to 3 meq/100 g or about 10 to 15% of the total exchangeable cations. If soil magnesium is greater than 1.6, pH greater than 6.5 and the calcium:magnesium ratio is 4, a magnesium fertiliser (dolomite, magnesium oxide) application is not recommended.

If magnesium is less than 1.6 meq/100 g, pH greater than 6.5 and the calcium:magnesium ratio is 4 or greater, apply magnesium oxide or Granomag at the rate of 100 to 200 kg/ha. Continue to monitor soil and leaf levels and soil and leaf calcium:magnesium ratios.

Sodium (meq/100 g Na, or cmol+/kg Na)

Sodium values should be less than 1.

Chloride (mg/kg or cmol+/kg Cl)

Chloride values above 50 mg/kg may limit tree growth and productivity. If chloride levels are high use the sulphate form of potassium.

Electrical conductivity (dS/m)

Electrical conductivity values up to 1.0 dS/m may be satisfactory. High electrical conductivity may only be a measure of residual salts from the previous fertiliser application. An analysis for chloride should always be used to determine salinity. If salinity values are higher, check possible sources such as irrigation water, the water table, soil and fertiliser type and rates. Persimmon yields and growth will decline under saline conditions.

Boron (mg/kg B)

Soils vary in their capacity to supply boron. Lighter textured soils that are often low in organic matter are generally lower in boron than heavier textured soils. Plant uptake is reduced under dry conditions. Heavy liming will reduce boron uptake. Soil values of 0.1 to 1.0 mg/1 kg represent a medium level of boron. Confirm a boron deficiency by leaf analysis. If boron is required apply 1 to 2 g of borax or 0.3 to 1.0 g of Solubor per square metre of soil surface beneath each tree.

Toxicity may develop if rates are too high. Continue to monitor with follow-up leaf analysis.

Zinc (mg/kg Zn)

Soil levels less than 2 mg/1 kg should be investigated further. If required, a soil application of zinc sulphate monohydrate should be applied at 2 to 3 g per square metre of soil surface beneath each tree. A spray of zinc sulphate heptahydrate at 2.5 kg/100 L can also be applied to dormant trees.

Fertiliser *program*

Persimmon production areas have different climatic and soil conditions. These differences mean orchards must be assessed individually, from the time of establishment to bearing.

Orchard establishment

Thorough land preparation is often neglected and trees planted without consideration being given to the nutritional status of the new orchard. Persimmon grow best in well-drained soil with a pH of 6.5. Soil testing at 0 to 15 cm and 15 to 30 cm deep helps determine lime (see *Liming*) and phosphorus requirements. If soil amendments such as lime or dolomite or phosphorus are required, apply before planting because lime takes four to five years to move through the profile from surface applications. Additional organic matter in the form of well-composted chicken manure can also be added at this time. Cross ripping the site will help trees develop a large root zone. Leave plenty of time between preparation and planting.

Fertilising young trees

Pre-planting

If the new orchard site is adequately prepared, then the main requirement after planting is for nitrogen fertiliser and adequate water to promote vegetative growth. This will develop the tree's framework so that in two to three years, high yields are achieved.

The only fertiliser required at planting is about 500 to 750 g of pelleted chicken manure per planting hole. This should be thoroughly mixed in the soil before planting. The addition of composted, organic fertilisers at this stage is preferred because artificial-type fertilisers can burn and injure roots.

After planting

If the soil has been well prepared, very little fertiliser other than nitrogen will be required during the first year. Urea, ammonium nitrate or calcium nitrate could be applied with irrigation every six to eight weeks. A nitrogen rate of 10 to 15 kg/ha should be adequate. Divide this rate by the number of trees per hectare to determine how much should be applied to individual trees.

If a mixed fertiliser is used, select one with an N:P:K ratio of about 14:2:10. Avoid fertilisers containing sulphate of ammonia because they are more acidifying than other nitrogen sources. However fertilisers such as urea and ammonium nitrate will gradually acidify soil over time.

Apply the fertiliser around each tree instead of broadcasting because the tree roots only explore a small volume of the soil. Do not apply fertilisers against the trunk of the tree and always water in after application.

Fertilising bearing trees

Factors affecting rates of fertiliser application

Trees growing in a subtropical climate and entering their third or fourth year, providing they have grown well, can carry a commercial crop. 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, i.e. the amount removed by the fruit;

- the amount of nutrient removed from the orchard in leaves and prunings;
- the amount of nutrient leached through the soil profile or washed from the soil surface;
- the amount of nutrient 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 and 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 soils with little clay and low organic matter.

It is difficult to assess with any confidence how much nutrient is lost from leaching because soil type and weather conditions vary so much.

Some limited data for losses in persimmon orchards in Japan is provided in *Review of persimmon nutrition literature*.

The following losses can occur:

- 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 washed away by runoff.

The figure for phosphorus will be dependent on soil type. In sandy, shallow (e.g. podzolic) soils 75% of applied phosphorus may become unavailable to plants, while in deep, red (e.g. krasnozems) soils, 95% could become unavailable. Persimmon phosphorus requirements 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 fertiliser can be lost to the atmosphere. For example, if urea or animal manure-based fertilisers are not incorporated into the soil by either cultivation or water then significant amounts of ammonia can be lost.

Fertiliser rates

Crop removal rates for different nutrients are often used to develop a basic fertiliser schedule for tree crops. However,

Table 4. *Crop removal rates compared with the fertiliser rates[1] recommended in Australia, Japan and New Zealand*

Nutrient	Fertiliser rates (kg/ha per year)			
	Crop removal rate (kg/ha)	**New Zealand**	**Japan**	**Australia**
Nitrogen	25	125	113	90
Phosphorus	5	70	68	15
Potassium	35	125	90	120
Calcium	2.5	-	-	150
Magnesium	1.2	70	-	70

[1] These rates are about three to four times greater than the crop removal rates for a 20 tonne crop. These revised 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.

Table 5. *New fertiliser rates and timing for Australia*

Nutrient	Fertiliser rate (kg/ha)[1]			Total rate per year
	Budbreak	**Late December/early January**	**Mid-harvest[2]**	
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.

[2] For most regions, mid-April for Fuyu.

using crop removal rates to develop a fertiliser schedule without allowing for losses by leaching and other causes would severely underestimate the fertiliser requirements required for maximum yields for most soil types. There may be some highly fertile soil types such as krasnozems, however, where the crop removal rates and a smaller allowance for leaching (30 to 100%) would be adequate.

Fertiliser rates should be based on calibration rates and timing experiments such as those conducted at Gatton and Nambour in Queensland. Based on these experiments, the optimum rates of nitrogen to apply appear to be 90 kg/ha. With potassium, yield and average fruit weight were still increasing with the highest rates of potassium applied. Based on extrapolation of the yield curves, a rate of 120 kg of potassium per hectare appears to be appropriate. From these experiments the nitrogen and potassium rates recommended are similar to the average rates recommended in Japan and New Zealand for mature trees (Table 4).

Fertiliser timing

The optimum timing for nitrogen application appears to be a very low rate at budbreak followed by a higher rate in mid-summer. Excessively heavy applications before fruit set increase fruit drop. The timing of potassium fertiliser appears to be less critical, however, on low calcareous soil types, heavy potassium applications at budbreak and during fruit set may displace calcium uptake during its period of maximum absorption. Based on both Australian and Japanese studies, we recommend that the annual nitrogen, phosphorus and potassium fertiliser requirement be split into three applications:

- 20% applied at budbreak;
- 60% in January;
- 20% during mid to late harvest (about mid-April, all regions).

Applications of nitrogen and potassium during late harvest should not adversely affect fruit quality but maintain leaf health and prevent premature defoliation, which reduces the build-up of starch reserves for next season's growth. A schematic diagram showing the pattern of nutrient uptake for different nutrients is shown in Figure 25 and the rates applied for the different times in Table 5.

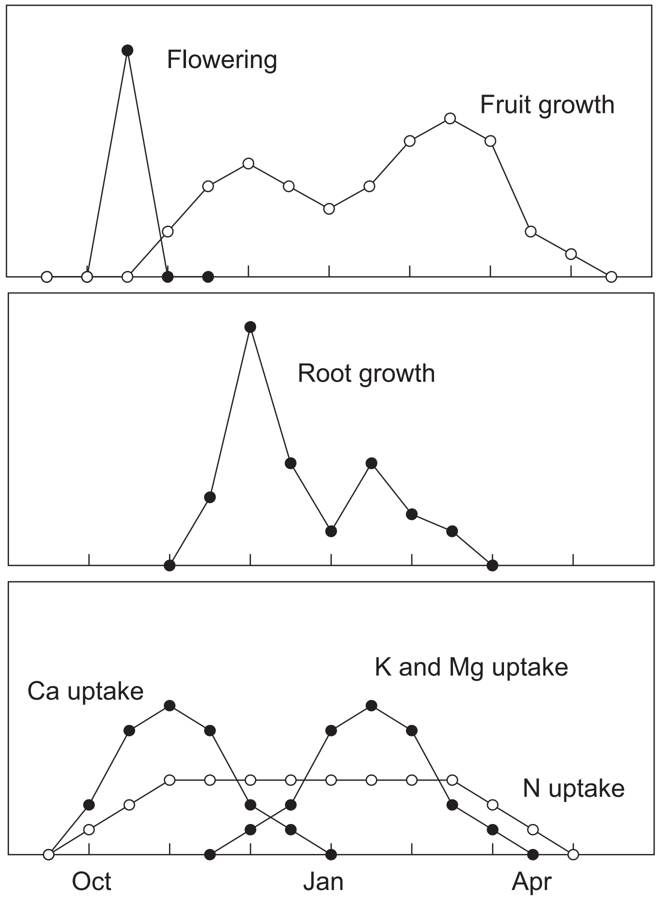
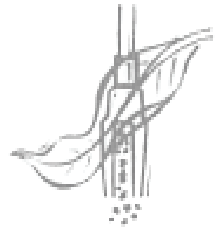


Figure 25. *Schematic diagram showing the major nutrient uptake periods*



Choosing a fertiliser

Fertilisers are often categorised as either organic or inorganic. Organic types are claimed to be derived from natural ingredients such as animal manures or vegetable matter, while inorganic fertilisers are often manufactured. Urea is a manufactured organic compound that is extremely soluble and is rapidly available to plants. The plant will benefit from both sources of nutrients. However, plants absorb nutrients in the inorganic form as nitrate ions ($N0_3^-$). Tree crops will also absorb ammonium ions (NH_4^+).

Types of fertilisers

Organic fertilisers

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

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

Where organic matter is applied as a nutrient improvement, nutrient release rates 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, while lower in nutrients, may be an alternative.

Mill mud, a by-product of sugar-cane milling, is generally available to orchards in subtropical and coastal districts.

Volatilisation of ammonia can be high from any fertiliser where nitrogen is in the ammonium form. These include 'natural' organic fertilisers and particularly those derived from fowl manure, urea and ammonium nitrate. These fertilisers should be rapidly incorporated into the soil where they can 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 higher proportion of nitrogen will be lost to the atmosphere as ammonia.

Organic fertilisers generally have low levels of nutrient and application rates should be adjusted for this. Extra

Table 6. *Nutrient range for some commonly used organic fertilisers*[1]

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	0.5 – 1.0	0.1 – 0.3	0.4 – 0.5
Sheep	0.9 – 1.8	0.3 – 0.4	0.3
Horse	0.6 – 0.7	0.1 – 0.3	0.4 – 0.6
Pig	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

[1] Wide variation in composition of some products such as poultry manure is due to differences in moisture content and source.

nitrogen and potassium will be required. A layer of plant mulch over fowl and other animal manures will reduce nitrogen losses from volatilisation of ammonia. The composition of some commonly used organic fertilisers is shown in Table 6.

Inorganic (manufactured) fertilisers

Inorganic fertilisers are available as 'straight' nutrient sources or as mixtures. Straight fertilisers are cheaper than mixed. Mixed fertilisers (N:P:K) are convenient to use, particularly in non-bearing trees. The 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 right fertiliser

Before selecting a fertiliser consideration should be given to soil type, nutrient status, pH, the amount and form of fertiliser required, and the cost.

Soil type

Light sandy soils have a low nutrient-holding capacity and will leach, so a slow release fertiliser or frequent applications of small amounts 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, levels and balance of nutrients and salt level. Leaf analyses can be useful in diagnosing 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

Due to the sensitivity of persimmon to chloride ions, **the chloride form of potassium should not be used**.

Little or no information is available on whether persimmons prefer to take up nitrogen in the ammonium (NH_4^+) or nitrate (NO_3^-) ion form (Table 7). However, to maintain the balance with calcium, **the calcium nitrate formulation may be more desirable** to use than other formulations of nitrogen, even though it is more expensive.

There is also some Japanese evidence which shows that it may be better to use slow-release, complete fertilisers at budbreak rather than straight fertilisers, which may promote excessive growth during fruit set.

Table 7. *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 both ion forms depending on soil type

Leaching and volatilisation losses

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

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

Acidification

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

Most nitrogen fertilisers acidify the soil because of nitrate leaching. Nitrate is a negatively charged ion and attracts cations such as calcium, magnesium and potassium that are leached through the profile.

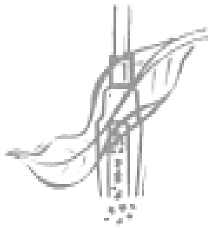
Roots take up calcium nitrate more readily in an alkaline environment. Calcium nitrate raises the soil pH slightly by the addition of a soluble form of calcium to the soil and this allows much greater movement of calcium than from the relatively insoluble lime (calcium carbonate). Most mixed fertilisers are based on ammonium sulphate and, thus, acidify the soil.

Table 8 shows the acidifying effect of various fertilisers by calculating the amount of lime required to readjust the soil pH to its original value.

Table 8. *Amount of 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	5.4
	mono-ammonium phosphate	3.5
Moderate	di-ammonium phosphate	1.8
Slight	urea	1.8
	ammonium nitrate	1.8
	potassium nitrate	2.0
Alkaline	calcium nitrate	–1.35

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



Fertigation

Fertigation is the application of nutrients through the irrigation system. It has many advantages:

- Nutrients can be applied to plants in the correct dosage and at the time appropriate for a specific stage of plant growth.
- Labour savings.
- Energy savings.
- Greater flexibility in timing.
- More efficient nutrient uptake.
- Reduced fertiliser use.

Because fertigation allows small amounts of fertiliser to be applied to the root zone and immediately incorporated into the soil, losses of nutrients can be minimised. For example, about 25% of the nitrogen applied as a broadcast application is taken up by the trees, the rest is leached out of the soil system. Irrigation must not exceed the water-holding capacity of the soil otherwise leaching will occur, reducing fertiliser efficiency and use.

Fertigation is ideal for low to medium volume under-tree systems. It is aided by the availability of specially-made, water soluble fertilisers.

Table 9. *Typical solubility of a range of nutrients in water at 20°C*

Product	Practical solubility[1] (kg/L)
Ammonium nitrate	1.92
Ammonium sulphate	0.75
Calcium nitrate	1.29
Di-ammonium phosphate	0.65
Potassium chloride	0.34
Potassium nitrate	0.32
Potassium sulphate	1.11
Urea	1.19
Sodium borate	0.25
Zinc sulphate	0.54
Magnesium sulphate	0.33
Liquifert N	0.3
Liquifert Lo-Bi	0.3
Liquifert P	0.4
Liquifert K Nitrate	0.3
Liquifert K	0.3
Liquifert K Spray	0.1

[1] Practical solubility is the realistic, in-field amount of product expected to be able to be dissolved. It is less than that achieved under laboratory conditions.

Solubility

Assuming the irrigation system is suited for fertigation with a suitable injection unit and a good filtration system, the choice and mixing of fertilisers will depend on solubility and compatibility (Table 9). 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; phosphorus, di-ammonium and mono-ammonium phosphates.

Compatibility

The combination of two or more fertilisers can lead to the formation of insoluble solid deposits (precipitates) which block the 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.

(A chelated product prevents a minor nutrient from reacting with other salts; however, they are not completely stable. For example, at high concentrations iron chelate will precipitate phosphate).

- Sulphates added to a solution containing calcium (e.g. if magnesium sulphate were added to calcium nitrate solution, a calcium sulphate precipitate would form).

Injecting into the system

There are several key points for a successful fertigation system.

- Fertiliser can be provided in different frequencies: 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, do not add too much at any one time. This will ensure that the product dissolves 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 either venturi, 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 the right fertiliser dose is given to each tree.
- With fertigation, it is best to divide fertiliser rates into many applications for the most efficient nutrient uptake. Therefore, fertiliser rates will need to be reduced. Nitrogen rates can be reduced by up to 50% and potassium rates by up to 25%.
- Leaf analysis should be done to ensure the fertilising rates are correct.

Foliar *fertilising*

Foliar fertiliser application is sometimes promoted as an effective means of supplying nutrients to persimmon. Various products are being promoted as foliar nutrients for subtropical fruits such as persimmon and some proponents even suggest that their products do away with the need for soil-applied nutrients. Many of these products are expensive to buy.

The most commonly applied foliar nutrients are calcium and boron. Foliar applications of these nutrients have effectively controlled internal disorders such as bitter pit in apple and blossom-end rot in tomato. However, the response to foliar applications of these nutrients in most subtropical fruits has been poor. The main reason is probably the excessively high vigour of subtropical trees grown under subtropical climates.

The **best options** for improving fruit quality characteristics such as fruit firmness and storage life in persimmon are to:

- raise soil pH through liming (for persimmon pH 6.5 to 7.0);
- raise soil calcium concentrations (greater than 8 meq calcium/100 g);
- maintain a balance of cations in the soil;
- obtain greater soil uptake of calcium and boron by the tree by avoiding water stress during fruit set;
- improve soil organic matter, humus and cation exchange capacity;
- control overall tree and shoot vigour to reduce shoot/fruit competition.

Foliar application of nutrients may only be beneficial under the following conditions:

- when trees show obvious deficiency symptoms;
- during periods of reduced nutrient uptake caused by either low soil temperatures, water stress or other factors.

Responses to foliar applications are often variable and inconsistent for several reasons. These are:

- low concentrations and small amounts of nutrients applied (Table 10);
- poor absorption through waxy leaf cuticles;
- limited mobility of nutrients such as calcium, phosphorus, zinc, boron and iron in the plant;
- strongly-growing shoots competing more effectively for nutrients than the fruit, especially when the fruit have just set.

To achieve improved efficacy from foliar applications, it may be necessary to:

- control tree growth first by summer pruning or other methods;
- apply multiple sequential applications (at least 6 to 12 sprays);
- apply at sufficiently high rates to achieve the maximum amount of nutrient to the leaf but not too high so as to cause phytotoxicity;
- apply in conjunction with non-ionic wetting agent to increase uptake (if applied with other pesticides wetting agents may already be added);
- apply during critical periods of fruit growth, e.g. fruit set.

The following cautions are advisable:

- Do not apply to unhealthy trees.
- Apply foliar sprays under rapid drying conditions to reduce risk of leaf and fruit burn but not on excessively hot days (greater than 30°C).
- Mix thoroughly in spray tank.
- Do not mix calcium chloride with Solubor or Epsom salts.

- It may be possible to mix foliar sprays with other pesticides but check response first on a few trees only before spraying whole blocks.
- Some formulations such as calcium chloride may increase pH of spray solution and may require the addition of weak acids, e.g. vinegar, to neutralise the solution.

Leaf nutrient analyses

Leaf analysis is a recommended tool to assist in the monitoring of leaf nutrient concentrations. Leaf samples should be taken at fruit set and one month before the start of harvest. If samples are taken at fruit set and leaf calcium concentration is found to be low, then foliar sprays can be started. Often soil calcium uptake is completed within one to two months after fruit set, and there is little further chance of increasing fruit calcium concentrations before harvest. Fruit nutrient analyses may also be beneficial, but samples would need to be taken at the end of Stage I of fruit growth and not at harvest as nutrient concentrations at this time are extremely low and difficult to detect.

Note: Growers need to be aware that deposits of nutrients on the leaf surface can give high readings (e.g. where copper fungicides are used), which could lead to erroneous conclusions. Thoroughly wash leaf samples in distilled water before sending away for analyses.

Monitoring

We highly recommend that growers monitor the effectiveness of foliar nutrient sprays. To do this, we suggest the following program:

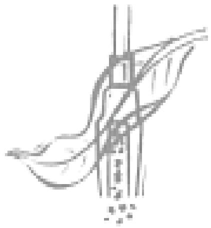
- Leave some rows unsprayed as controls; this is very important.
- To increase the chances of response, spray a few trees twice so that they receive double the amount of sprays (this may cause phytotoxicity).
- Take a leaf sample for nutrient analyses at fruit set and one month before harvest.
- Take a fruit sample for nutrient analyses at the end of Stage I of fruit growth.
- At harvest, take a fruit sample of 20 to 30 fruit for fruit quality measurements (weight, colour, sugar concentration, firmness).
- Take a sample from both controls and sprayed trees for storage at shelf temperature and at the recommended cool storage temperature. Count the number of soft fruit at three- to four-day intervals.

Table 10. *Calcium concentration, content and price for some commonly used, commercially available, foliar nutrients. (Listing of the products does not imply endorsement and are only provided for comparison. Follow product label directions at all times.)*

Product	Calcium (%)	Calcium (g/L or g/kg)	Calcium applied per tree (g)	Price in store November 2000
Wuxul™[1]	10.7	107 g/L	1.6	$81.68 per 10 L
Stopit™[1]	16	160 g/L	2.4	$52.80 per 10 L
Vigor Cal™[1]	5.9	59 g/L	0.9	$84.70 per 10 L
Seniphos™[1]	4	40 g/L	0.6	$69.50 per 10 L
Cal-tech™[1]	12%	120 g/L	1.8	$35.20 per 5 L
Calcium nitrate[2]	18	180 g/kg	1.4	$20.70 per 25 kg
Calcium chloride flakes[2] (75% $CaCl_2$)	27.8	278 g/kg	2.1	$35.00 per 25 kg

[1] Assumes a rate of 10 L of product per hectare per spray with all spray applied to leaf surface, 650 trees per hectare.

[2] Assumes a concentration of 0.1%, 8 L per tree per spray with all spray applied to leaf surface, 650 trees per hectare. Price will vary according to agents and is provided as a guide only.



Comparing fertiliser costs

To compare the cost of different fertilisers, the price per tonne (including GST) and the percentage of the nutrient in the fertiliser needs to be known. The prices shown below were obtained from a farm supplies outlet in south-east Queensland on 9 November 2000. Fertiliser prices vary and the costs calculation should be checked regularly. Examples provided are a guide only.

Straight fertilisers

Calculations are as follows:

(a) kg of actual nutrient in 1 tonne (t) of fertiliser
= % of nutrient x 10

(b) cost per nutrient = $\frac{\text{cost per tonne}}{\text{kg of nutrient per tonne}}$

Examples

Nitrogen

1. Urea (46% nitrogen) is $536.25/t or 25 x 40 kg bags @ $21.45 each (25 bags per tonne) $536.25 ÷ 460 kg = $1.17/kg of N
2. Nitram (ammonium nitrate, 34% nitrogen) is $506.00/t or 20 x 50 kg bags @ $25.30 each (20 bags per tonne) $506.00 ÷ 340 kg = $1.49/kg of N
3. Gran-am (ammonium sulphate, 20.2% nitrogen) is $481.25/t or 25 x 40 kg bags @ $19.25 each (25 bags per tonne) $481.25 ÷ 202 kg = $2.38/kg N
4. Calcium nitrate (15% nitrogen) is $828.00/t or 40 x 25 kg bags @ $21.67 each (40 bags per tonne) $866.80 ÷ 150 kg = $5.78/kg N

In this example urea is the cheapest of these four nitrogen fertilisers but other factors need to be taken into account when selecting the type of fertiliser to use.

Phosphorus

1. Single superphosphate (8.8% phosphorus) is $350.00/t or 20 x 50 kg bags @ $17.05 each (20 bags per tonne) $350 ÷ 88 kg = $3.98/kg P

Potassium

1. Muriate of potash (50% potassium) is $511.50/t or 25 x 40 kg bags @ $20.46 each (25 bags per tonne) $511.50 ÷ 500 kg = $1.02/kg K
2. Sulphate of potash (41% potassium) is $906.25/t or 25 x 40 kg bags @ $36.25 each (25 bags per tonne) $906.25 ÷ 410 kg = $2.21/kg K
3. K Spray (K-Nitrate or Potassium Nitrate) (41.5% potassium) is $1148.40/t or 40 x 25 kg bags @ $28.71 each (40 bags per tonne) $1148.60 ÷ 383 kg = $2.77/kg K

Mixed fertilisers

Costing mixed fertilisers is difficult because the cost of each element may not be known. If the form of each element in the mix is known, the cost of making a mix can be compared.

Examples

1. Nitrophoska Blue (12% N, 5.2% P, 14.1% K, 4.3% Ca, 1.2% Mg, 0.01% Zn, 0.02% B, 6.0% S) is $748.00/t or 25 x 40 kg bags @ $29.92 each (25 bags per tonne)
2. Greengrove TE (13.2% N, 3.3% P, 12.3% K, 12.9% S, 0.8% Zn, 0.5% B, 12.9% S) is $651.75/t or 25 x 40 kg bags @ $26.07 each (25 bags per tonne)
3. Fertica (11.7% N, 6.5% P, 12.9% K, 0.7% Mg, 0.4% Zn, 0.3% Cu, 0.2% B, 13.2% S) is $720.50/t or 40 kg bags @ $28.82 each (25 bags per tonne)

4. 77 (S) (13.0% N, 2.2% P, 13.3% K, 18.7% S) is $649.00/t or 25 x 40 kg bags @ $25.96 each (25 bags per tonne)
5. 77 (S) Cu, Zn (12.2% N, 1.9% P, 12.5% K, 0.9% Cu, 0.85% Zn, 18.5% S) is $748.00 or 25 x 40 kg bags @ $29.92 each (25 bags per tonne)

The nutrient composition of a range of commonly used mixed fertilisers is shown in Table 11.

Mixing your own fertiliser

Some growers prefer to mix their own fertiliser rather than buy ready mixed. First select the N:P:K ratio required. If the form of each element in the mix is known, the cost of making a mix can be compared with mixed fertilisers. Some ingredients should be used quickly after mixing because they may set or go lumpy. Mixing the fertiliser for immediate use is best. If the orchard does not have an acid subsoil or an excess potassium problem you can use urea for nitrogen, single superphosphate for phosphorus and muriate of potash for potassium.

Examples

Comparing the cost of 77 (S) with making your own mix of the same composition from straight fertilisers.

In one tonne of 77 (S) there is:

- 130 kg of nitrogen
- 22 kg of phosphorus
- 133 kg of potassium.

From the earlier examples, urea nitrogen costs $1.17/kg, single superphosphate phosphorus costs $3.98/kg and muriate of potash potassium costs $1.02/kg. The cost of mixing this compound fertiliser is:

- 130 kg (urea) nitrogen x $1.17 = $152.10
- 22 kg (single superphosphate) phosphorus x $3.98 = $87.56
- 133 kg (muriate of potash) potassium x $1.20 = $159.60

Total cost of own mix = $399.26

Compared with:

Total cost of 77 (S) = $649.00

By mixing straight fertilisers you would save $249.74 per tonne.

Comparing liming product costs

Lime products differ in their neutralising value (NV) and fineness. Two simple calculations will help to compare the products' efficiency and cost:

- efficiency = (fineness x NV) ÷ 100
- comparative cost = (spread cost x 100) ÷ efficiency

Note: Actual purchase cost of product is not included in the calculations. Spreading costs will vary with type of product and the contractor used to spread it. Contact you local contractor to determine actual costs of spreading each product.

Table 11. *Kilograms of nutrient in one tonne of mixed fertiliser*

Element	Nitrophoska Blue	Greengrove TE	Fertica	77 (S)	77 (S) Cu, Zn
Nitrogen (N)	120	132	117	130	122
Phosphorus (P)	52	33	65	22	19
Potassium (K)	141	123	129	133	125
Calcium (Ca)	43	–	–	–	9
Magnesium (Mg)	12	–	7	–	–
Zinc (Zn)	0.1	8	4	–	8.5
Boron (B)	0.2	5	2	–	–
Copper (Cu)	–	–	3	–	–
Sulphur (S)	60	129	132	187	185

For the exercises below, spreading costs of products have been based on a 25 tonne load or greater.

Spreading costs of a 25 tonne load
= approximately $14 per tonne plus 10% GST

To spread 25 tonne of product = 25 t x $14.00
= $350.00 + 10% GST

10% GST = $350.00 x 10 ÷ 100 = $35.00

Total cost of spreading 25 tonne of product = $385.00

Examples

Dolomite

Calcium (Ca) 14%, fineness 60%, NV 70%, $14/t spread by contractor

Efficiency = (60 x 70) ÷ 100 = 42

Comparative cost = ($14 x 100) ÷ 42 = $33.33/t

Aglime

Calcium (Ca) 36%, fineness 60%, NV 95.6%, $14/t spread by contractor

Efficiency = (60 x 95.6) ÷ 100 = 57.4

Comparative cost = ($14 x 100) ÷ 57.4 = $24.39/t

Superfine Lime

Calcium (Ca) 38.8%, fineness greater than 90%, NV 97.5%, $14/t spread by contractor

Efficiency = (90 x 97.5) ÷ 100 = 87.8

Comparative cost = ($14 x 100) ÷ 87.8 = $15.95/t

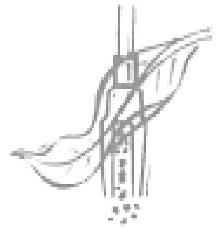
Grow-Mag

Calcium (Ca) 32%, magnesium (Mg) 8%, fineness 45%, NV 110%, $14/t spread by contractor

Efficiency = (45 x 110) ÷ 100 = 49.5

Comparative cost = ($14 x 100) ÷ 49.5 = $28.28/t

Note: The prices used in this section are examples only. Check all prices before making your calculations.



Liming

Most persimmon orchards are sited on naturally occurring, acid soils with only 30% of orchards surveyed having the ideal soil pH and soil calcium.

Optimum soil pH and calcium concentrations

The ideal soil pH and calcium concentrations for persimmon are:

- soil pH 6.5 to 7.0 (1:5 water);
- soil calcium concentration greater than 8 meq/100 g.

These appear to be the ideal levels required for obtaining firm fruit and longer storage life. Soil pH is often highly correlated with soil calcium so if you get the pH right then there is an increased probability that the calcium will be adequate.

Persimmon are also susceptible to green blotch disorder caused by excessive manganese uptake. Liming reduces soil availability of manganese, thus reducing the incidence of the disorder.

Soil acidity is compounded by the use of:

- acidifying fertilisers;
- leaching of nutrients such as nitrogen;
- removal of nutrient through crop removal;
- removal of organic matter.

Often lime or dolomite is applied without consideration being given to whether it is required. Before making this decision, do a soil test (preferably 0 to 15 cm and 15 to 30 cm) so the pH of both depths, and the relative balance between calcium and magnesium, are known.

The ratio of calcium to magnesium helps to determine whether to use lime or dolomite. Ideally, the calcium:magnesium ratio should be between 3:1 and 5:1. Dolomite, which contains both calcium and magnesium, should only be used when both calcium and magnesium are low and the ratio of calcium to magnesium is greater than 6:1.

Characteristics of liming materials

All liming material must meet Government standards before it is sold. Each year a list of registered liming materials is published. It provides valuable information on the calcium and magnesium content and neutralising values (NV) and a measure of fineness. The type of liming material will depend on soil pH, and soil calcium and magnesium concentrations.

There are four points to consider before buying lime or dolomite.

Purity

Some products contain impurities such as silica or clay. If these are high then more lime must be applied.

Neutralising value (NV)

Neutralising value is the ability of the liming material to neutralise acidity compared with pure calcium carbonate which has a neutralising value of 100. Select a product with a high neutralising value, i.e. a lime with a neutralising value of at least 75%. Some of the more important agricultural liming and magnesium-containing products are shown in Table 12.

Forms of lime

These are the most commonly used forms of lime:

- Agricultural lime, which is the most widely used form of lime, is sold as finely ground calcium carbonate.
- Slaked lime and quick lime are quicker acting than agricultural lime, but are rarely used commercially.
- Dolomite is a mixture of calcium and magnesium carbonates and rarely contains more than 10%

Table 12. *Calcium and magnesium content and neutralising values (NV) of a range of agricultural liming and calcium- and magnesium-containing materials*

Product	Formulae	% calcium	% magnesium	NV
Calcium carbonate (pure)	$CaCO_3$	40	-	100
Dolomite (pure)	$CaMg (CaCO_3)_2$	21.7	13.1	108
Quick lime (pure)	CaO	71.5	0	178
Slaked lime (pure)	$Ca(OH)_2$	54.1	0	134
Agricultural limes	$CaCO_3$	30 – 40	0	20 – 99
Agricultural dolomite	$CaMg (CaCO_3)_2$	15 – 30	3 – 9	70 – 100
Grow-Mag	$MgO + CaCO_3$	32	8	110
Magnesium oxide (Granomag)	MgO	0	54	–
Epsom salts	$MgSO_4$	0	10	–
Gypsum	$CaSO_42H_2o$	21	0	–

magnesium. Dolomite is mainly used on light soils under high rainfall where deficiencies of both magnesium and calcium occur.

- Grow-Mag is a mixture of magnesium oxide and calcium carbonate. It is claimed to be more fast acting than dolomite and it supplies the calcium and magnesium in a more desirable soil ratio, i.e. about 4:1.
- Gypsum is not a liming material, but is neutral in its effect on soil reaction. It is used when soil calcium levels are low, but pH is adequate, and as method of improving the structure of high sodium soils.

Note: At very low soil pH, the addition of gypsum may have a detrimental effect on tree growth by displacing the more toxic aluminium and hydrogen ions from the soil exchange sites.

Fineness

Lime is very insoluble and a finely ground product is required to achieve a beneficial result. Particles should be fine enough for 80% to pass through a 0.6 mm sieve. Particles greater than 2 mm are ineffective. Lime is also very slow moving through the soil profile. Ideally, it should be incorporated into the soil before planting the orchard. Liquid formulations of gypsum and lime are now available which should give, for some soil types, a more rapid response by placing the calcium in the wetted area of the root zone.

Application methods

Soil applications of lime are often slow-acting and often only raise the pH of the surface layers first. Lime, dolomite and gypsum are all relatively insoluble and therefore take several months to years to move down the soil profile and to raise soil pH. In addition high rates of lime can temporarily tie up trace elements such as zinc and iron.

Where a rapid increase in soil calcium is required soluble formulations of gypsum or lime may be applied through the irrigation.

Timing

Lime should be applied either to the planting row or site 12 months before planting. If applied during the wet season, it can be washed from the soil surface rather than into the soil. Light rain or irrigation does a better job of washing fine lime into the soil profile than heavy rain. If more than 2 t/ha of lime are suggested, apply half the first year and the remainder during the following season. Autumn is an ideal time to apply lime in coastal Queensland.

Liming rates

The amount of lime or dolomite required will depend on the change in pH required and the buffering capacity of the soil, which is the soil's ability to resist change in pH following the addition of lime (Figure 26). Buffering capacity is largely dependent on soil texture. A pH of 6.5 to 7.0 (in 1:5 water) is adequate for persimmon. Overliming can contribute to a nutrient imbalance and/or an iron and zinc deficiency. Some guidelines for rates to apply are:

- where pH needs to be adjusted no more than 2 t/ha is applied every 6 to 12 months;
- the soil pH and soil calcium:magnesium ratios should be monitored 6 to 12 months after each application so the liming requirement can be reassessed (Figure 27).

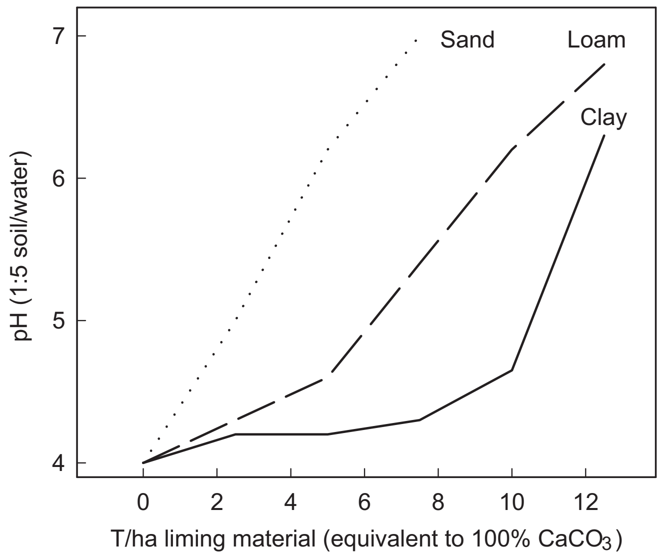


Figure 26. *Amount of lime (tonnes) required to raise soil pH to different levels. Do not apply all the lime at once*

Additional notes

- Do not apply lime soon after or just before boron applications. It is best to apply lime when it known that the last boron application has been well watered in.
- Lime, dolomite and gypsum rates given here should be broadcast over the entire ground area of the block. However, if you wish to treat a smaller area, e.g. under-tree only, then the rate should be reduced proportionately.
- Do not apply lime with ammonium fertilisers as nitrogenous gases may be released to the atmosphere.

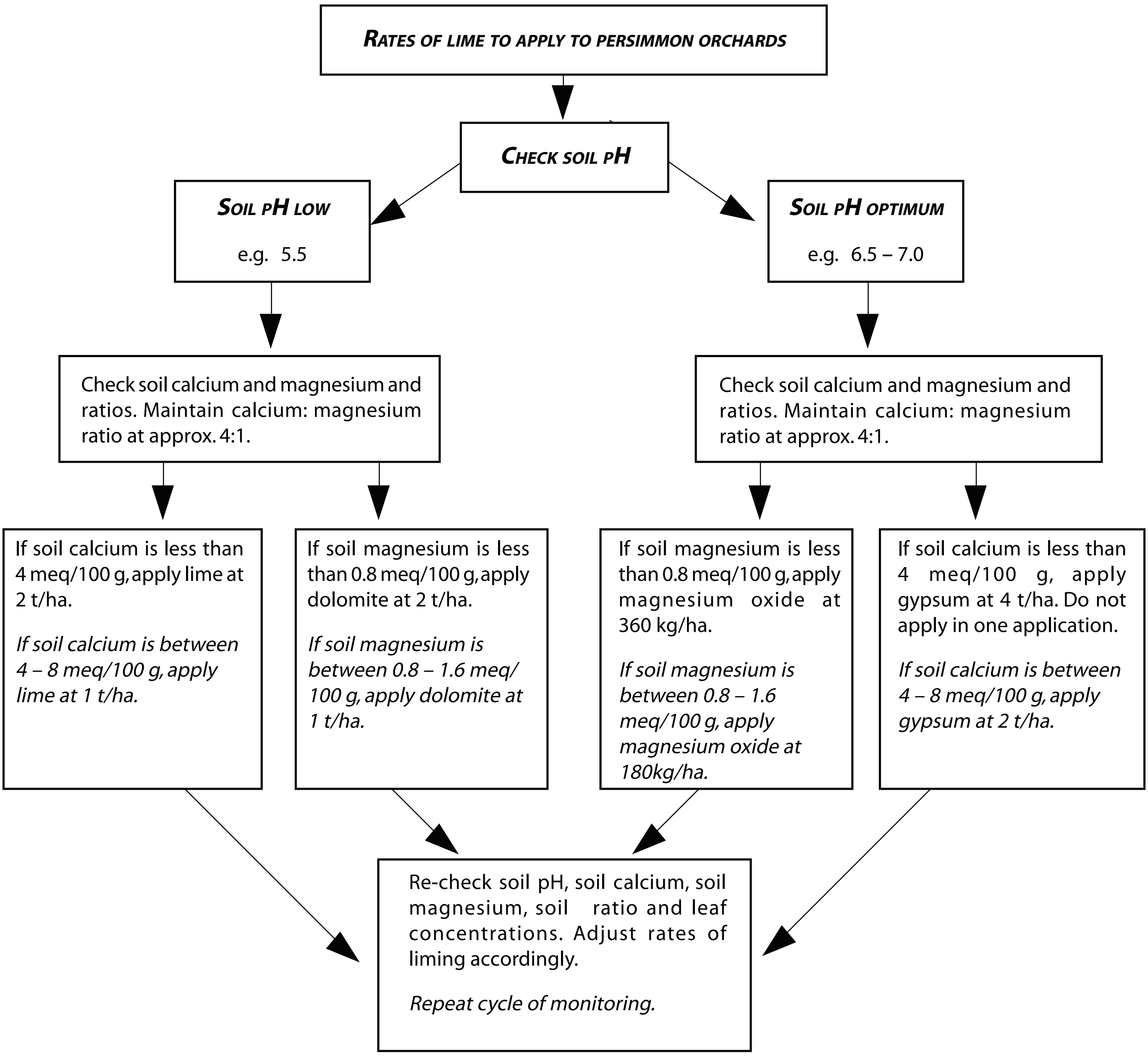


Figure 27. *A simple guide for liming persimmon orchards*

Salinity

Salinity has been found to cause major yield reductions in persimmon in Australia. Fruit size may be reduced by up to two size grades due to reduced photosynthesis and starch accumulation. Leaf chloride concentration greater than 0.8% significantly reduced the marketable yield (Figure 28).

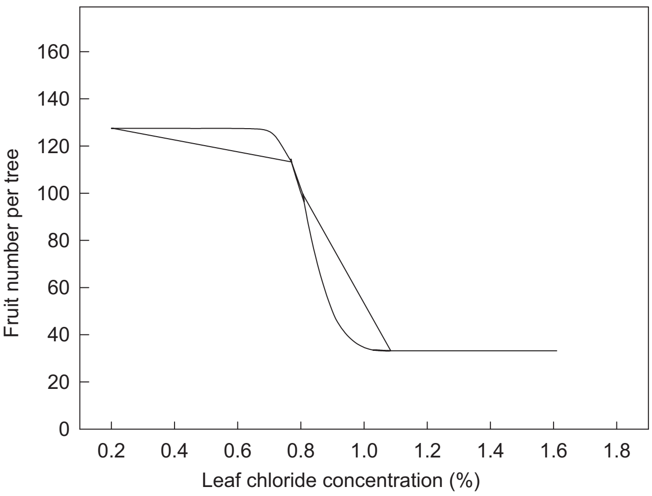


Figure 28. *Relationship between leaf chloride concentration and fruit number per tree of the non-astringent persimmon cv. Fuyu*

There are two types of salinity:

- primary salinity (from the soil);
- secondary salinity (from water, irrigation and natural water tables).

Methods to reduce salinity problems could include:

- reducing the source of salinity, a very long term solution;
- selecting rootstocks with tolerance to salinity, a medium term solution;
- altering irrigation practices (heavier less frequent irrigations);
- selecting fertilisers with low salt indices.

Some of these are discussed in more detail below.

Fertiliser selection to reduce salinity

Some fertilisers will increase salinity more than others so be aware of the salt indexes of the major fertiliser types shown in Table 13.

Normally, excess salts should be leached through the profile in a wet season. During dry times and periods of limited irrigation, either do not fertilise or select a fertiliser with a low salt index. Reduce fertiliser application rates where water from either rainfall or irrigation is limited.

Table 13. *Comparative ability of the same weight of each fertiliser to increase the salinity of the soil relative to sodium nitrate being given an index of 100*

Fertiliser	Salt index
Sodium chloride (table salt)	154
Potassium chloride (muriate of potash)	114
Ammonium nitrate	105
Sodium nitrate	100
Urea	75
Potassium nitrate	74
Ammonium sulphate	69
Calcium nitrate	53
Potassium sulphate (sulphate of potash)	46
Magnesium sulphate	44
Di-ammonium phosphate	34
Mono-ammonium phosphate	30
Triple superphosphate	10
Mono-potassium phosphate	8
Calcium sulphate (gypsum)	8
Single superphosphate	8
Calcium carbonate (lime)	5
Dolomite	1

Irrigation water quality

Salinity levels for both soil and water are expressed in terms of their electrical conductivity (EC, see Appendix B). For persimmon, which has a very low tolerance to salinity, irrigation water should have an electrical conductivity of less than 0.65 dS/m and a total dissolved ions of less than 400 mg/L (ppm).

Irrigation frequency

To reduce the risk of salinity developing from low quality water, it is preferable to irrigate less frequently with heavier quantities at each irrigation. This type of irrigation management allows the surface soil to be leached, thus avoiding salt accumulation in the root zone. Mulching may also be beneficial by reducing evaporation.

Leaf and tree *health*

During the season, and particularly after harvest, maintaining leaf health will be important for improving tree carbohydrate status and nutrient reserves. Japanese studies have demonstrated that shoot starch depletion in the autumn as a consequence of heavy crop loads or early defoliation can reduce flowering, fruit set and fruit size in the following growing season.

During leaf senescence in autumn nearly 60% of the total leaf nitrogen is transported back to storage tissue within the tree for remobilisation in spring. If a tree has high leaf nitrogen before senescence then ample nitrogen will be present in storage tissue to support early stages of leaf, flower and fruit development the following season.

Storage of nutrients during autumn is an important mechanism in the recycling process.

Leaf health can be maintained by:

- controlling *Cercospora* leaf spot;
- maintaining leaf nitrogen.

Leaf spot can be prevented by routinely applying a protectant fungicide every two to three weeks during the season, depending on weather conditions.

Leaf nitrogen can be maintained by an application of nitrogen at mid-harvest, which, in most regions, is mid-April. Soil temperatures should be still high enough at this time for nutrient uptake.

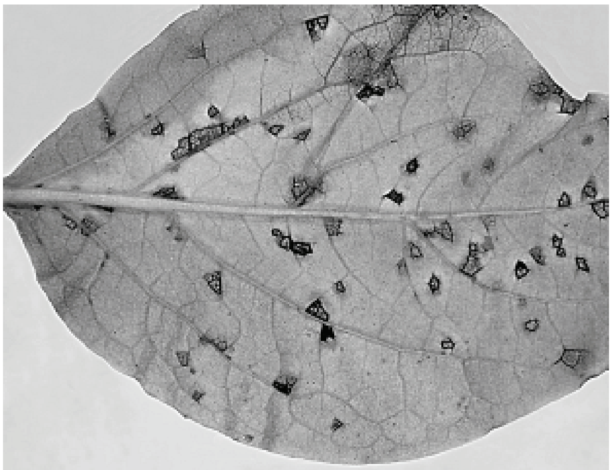


Figure 29. Cercospora *leaf spot*

Review of **persimmon nutrition** *literature*

The non-astringent persimmon industry is rapidly expanding in Australia with over 300 000 trees planted in the subtropical and warm-temperate regions. Development of management techniques to improve productivity and achieve high fruit quality are industry priorities. The nutritional requirements of persimmon grown in subtropical conditions are poorly understood and current fertilising practices are based on grower experience. Leaf sampling procedures for nutrient analyses and leaf nutrient standards are based on those established for persimmon in more temperate regions such as Japan and New Zealand.

Growth patterns

Persimmon is a deciduous fruit tree primarily grown in temperate regions of the world. Production has expanded into subtropical regions such as Australia and New Zealand in response to export market opportunities for out-of-season fruit in traditional Asian markets. Persimmon production may also be further expanded in tropical regions to meet domestic demand, for import substitution and for the establishment of export industries.

The growth of tree fruit species, whether they be evergreen or deciduous, follows a cyclic seasonal pattern which is repeated each year, though not necessarily on the same time scale or with the same intensity of growth for each stage.

Three separate growth organs can be easily distinguished: root, shoot and reproductive. While they are dependent on each other, they do compete for limited tree nutrients and carbohydrates and, if the vegetative to reproductive balance is not maintained, fruit yield is ultimately reduced. By recognising the stages of growth and understanding their requirements and the interactions within the tree, management practices can be modified and programmed to develop strategies which lead to productivity gains.

The growth patterns for non-astringent persimmon have only been partially described, with virtually all studies being conducted under cool subtropical or temperate climates in Japan. Most of these studies have evaluated only one aspect of the cycle, usually in isolation to the rest. The growth patterns for persimmon in subtropical Australia are shown in Figure 30.

Root growth and distribution

In Japan, for mature trees, roots were found to be distributed up to 5.5 m horizontally and penetrated a depth of 140 cm. About 50% of the total roots occupied the 20 to 40 cm depth. Root depth has important implications for many management procedures such as depth of soil sampling, liming and fertiliser placement. With potted trees of cv. Nishimurawase, root nitrogen content fell during October due to mobilisation and translocation to new growing shoots, but increased two to three months before harvest.

Seasonal leaf and shoot nutrient patterns

Seasonal leaf nutrient patterns for persimmon in Australia (Figure 31) are similar to those established for persimmon in Japan, China and New Zealand, and for temperate fruits in general. One group of nutrients (nitrogen, phosphorus, potassium) showed a general decline in concentration, another group (calcium, magnesium, boron) showed an increase, while another group (copper, zinc) remained relatively constant. The pattern of nutrient decline over the growing season has been associated with growth dilution effects, while the pattern of increase is associated with nutrients such as calcium, which have little mobility in the phloem (the food-conducting tissue in plants). Shoot nutrient patterns followed a similar pattern to leaf nutrients. The seasonal patterns for specific nutrients are described below.

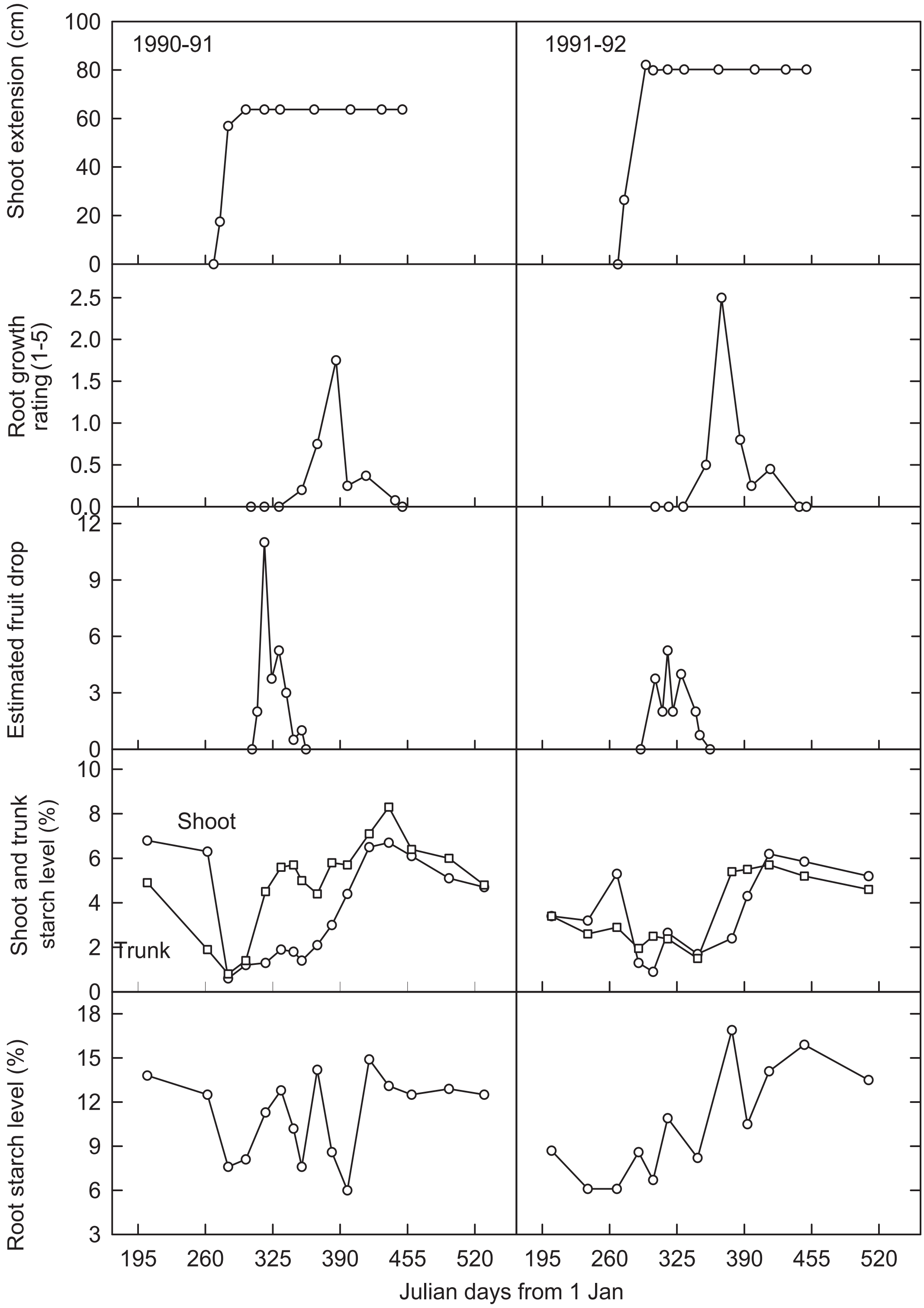


Figure 30. *Growth patterns and seasonal changes in starch of the non-astringent persimmon cv. Fuyu at Palmwoods, Queensland, over two seasons*

Typically, nitrogen shows a fairly steady decrease from about 3.5 to 1.5% through the season. Phosphorus decreases quickly from 0.32 to 0.14%. Potassium declines markedly in the latter half of the growing season. Leaf potassium levels sometimes fall below 1%, a level which is considered deficient in temperate, deciduous fruits such as apples and peaches. The effects of heavy fruiting inducing potassium deficiency has been shown for a range of fruit crops including peaches, citrus and pecan. The fall in leaf potassium levels may be due to remobilisation of leaf potassium to the developing fruit. Pollinated (seeded) fruit may also have a higher demand for potassium, as indicated by a 20% higher concentration of potassium compared with non-pollinated (nil or few seeds) fruit. Leaf contents of both calcium and magnesium increase through the season, especially during the late summer.

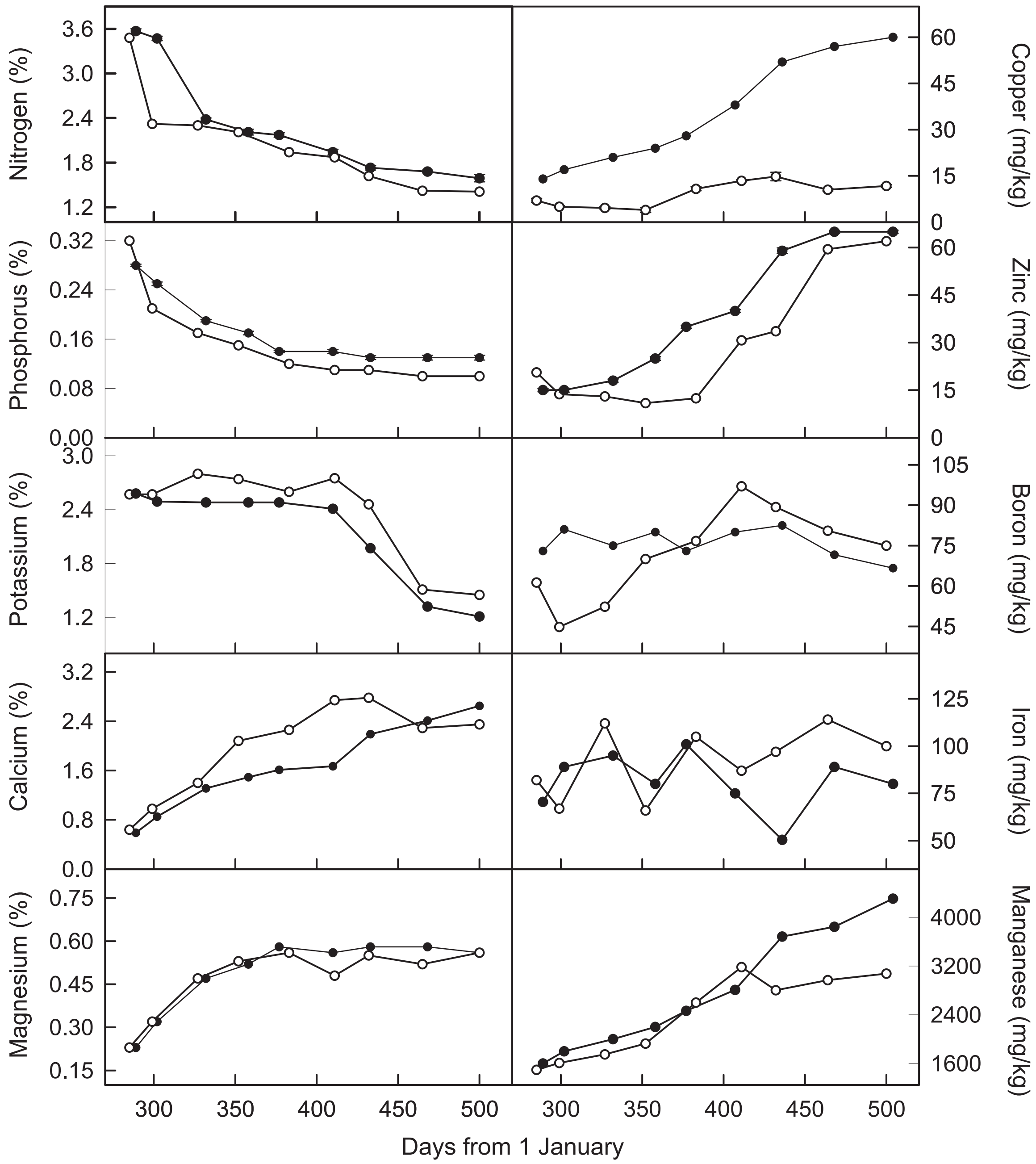


Figure 31. *Seasonal changes in leaf nutrient concentrations of the non-astringent persimmon cv. Fuyu at Palmwoods, Queensland, over two seasons*

In Australia, with the exception of a short period six weeks after the start of flowering, concentrations of calcium and magnesium levels increased in the leaves as the season progressed, a pattern typical for nutrients of low or intermediate mobility. These patterns were similar to those found for persimmon in New Zealand and Japan. The fall in calcium and magnesium levels after flowering may be due to the high demand for these elements by the developing fruits.

Studies in New Zealand show that as much as 80% of the persimmon fruit's calcium requirements may be taken up during the first three months after the start of flowering, a period they considered to be crucial for calcium uptake by the fruit.

Boron and iron levels fluctuate during the season, whereas copper, iron and manganese levels all increase through the season. Manganese levels are naturally high in the acidic soils of many coastal regions of eastern Australia. Concentrations of copper and zinc in persimmon leaves, irrespective of cultivar, are low in comparison with those for pome and stone fruits. In New Zealand, symptoms of copper and zinc deficiency in persimmon seedlings grown in sand culture are only observed at leaf concentrations below 1.5 mg/kg for copper and 4.0 mg/kg for zinc.

Table 14. *Effects of canopy position on leaf nutrient levels of the non-astringent persimmon cv. Fuyu under subtropical conditions of Australia*

Treatment	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Cu (mg/kg)	Zn (mg/kg)	B (mg/kg)	Fe (mg/kg)	Mn (mg/kg)
Top	2.16	0.13	1.75	1.66	0.57	5.1	53.0	122.8	77.3	1118
Middle	2.20	0.13	1.99	1.63	0.57	5.7	91.4	121.1	92.9	1174
Base	2.17	0.13	2.19	1.71	0.59	5.4	128.2	118.2	114.2	1138

Table 15. *Effects of paclobutrazol and pollination on fruit and leaf nutrient concentrations of Fuyu persimmon. Data are the means of 10 trees*

Treatment	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Cu (mg/kg)	Zn (mg/kg)	B (mg/kg)	Fe (mg/kg)	Mn (mg/kg)
Fruit										
Hand-pollinated	0.95	0.19	1.42	0.11	0.05	3.1	8.1	17	18.8	131
Non-pollinated	0.84	0.18	1.17	0.09	0.05	3.1	6.6	17	17.8	129
Leaf										
Paclobutrazol	2.09	0.12	2.91	2.38	0.41	11.5	39.9	193	82.6	4818
No paclobutrazol	1.98	0.11	2.70	2.39	0.42	10.7	44.4	189	80.6	4619

For fruit, thinning and paclobutrazol effects and interactions were not significant (P = 0.05)
For leaf, pollination and thinning effects and interactions were not significant (P = 0.05)

Canopy position

Canopy position may also have an effect on leaf nutrient concentrations. Leaf potassium, zinc and iron increase with decreasing tree height (Table 14). In contrast, there is no significant effect of canopy height on the concentration of the other nutrients. Leaf calcium increases with fruit seed number, indicating that the seed is a major sink for this nutrient.

Crop load

Leaf potassium, calcium and manganese concentrations have been shown to fall with increasing crop load. The greatest falls are in leaf potassium (Figure 32), indicating that this nutrient is in high demand by the fruit.

Rootstock

Effects of rootstock on leaf nutrient composition in persimmon are poorly researched. Recent studies in China indicate differences in rootstock species. We also suspect there is wide genetic variation within rootstocks in their effects on calcium uptake, salinity tolerance, etc.

Flowering

Japanese researchers found a mild positive correlation with nitrogen concentration in the one-year-old wood, but not leaf, at the time of floral bud differentiation in December, and flower quality in the following season. They concluded that the nitrogen concentration in the one-year-old wood at the time floral buds are differentiating (December in Australia) is an important factor affecting the number and quality of flowers.

Pollination

Compared with non-pollinated fruit, pollinated fruit have significantly greater concentrations of nitrogen, potassium, calcium and zinc (Table 15). In contrast, pollination did not significantly affect leaf concentrations of other nutrients.

Several studies showed that both fruit set and fruit size were significantly improved by hand-pollination. The level of fruit set was similar to the highest levels of fruit set recorded for cv. Fuyu in Japan. As in previous studies in subtropical Australia, non-pollinated flowers abscissed (dropped) readily. The increased susceptibility of non-pollinated flowers to drop may be due to lack of pollination, low irradiance (light levels), water stress and excessive shoot growth resulting in severe competition between fruit and vegetative organs for assimilates (carbohydrates and

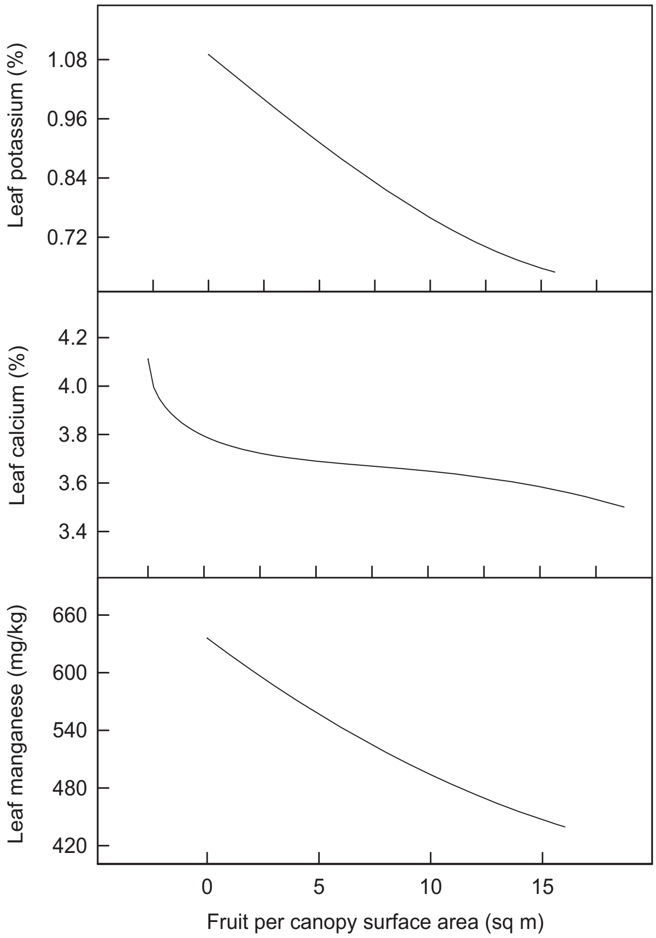


Figure 32. *Effects of crop load on leaf nutrient concentrations of the non-astringent persimmon cv. Fuyu*

nutrients). Since mature trees of cv. Fuyu can produce more than 2000 flowers per tree, orchards containing no polliniser trees and which are well managed can still set commercially acceptable crops.

Compared with non-pollinated fruit, pollinated fruit are more efficient in competing for dry matter, carbohydrates and nutrients, indicating that they exert a greater sink force for these nutrients, presumably through pathways mediated by plant growth regulators. Although many studies have shown the influence of fruiting on increasing leaf nutrients, few or no studies have shown the influence of pollination and seed development on raising leaf nutrients levels.

Increased photosynthesis of leaves adjacent to pollinated fruit is probably due to increased assimilate demand by the fruit. With other temperate fruits, increased leaf photosynthesis with fruiting has been reported for peach, but not for sweet cherry. Increased assimilate demand by pollinated persimmon fruit may also be responsible for the greater starch depletion of these shoots. Shoot starch depletion may have important implications on next season's crop. Japanese studies have demonstrated that shoot starch depletion in the autumn as a consequence of heavy crop loads or early defoliation can reduce flowering, fruit set and fruit size in the following growing season. Crop loading studies have shown that the depletion in shoot starch reserves as a consequence of low whole-tree thinning rates has deleterious effects on next year's flowering and fruit set.

Studies in Japan have shown that the ratio of seeded:seedless fruit on cv. Maekawa Jiro trees may influence fruit size, fruit colour and soluble solids. On trees where the seeded:seedless fruit ratio is high, seedless fruit were small, slow to develop colour and had low soluble solids contents. In contrast, on trees where the seeded:seedless fruit ratio is low, seeded and seedless fruit were similar in size, colour and soluble solids. These results also suggest that pollinated fruit compete more successfully for nutrients than seedless fruit. The increase in nitrogen, potassium, calcium and zinc in pollinated fruit may also have important consequence for fruit storage life. This aspect is being studied.

Growth retardants

Compared with control trees, paclobutrazol significantly increases leaf nitrogen, phosphorus, potassium concentrations (Table15, page 42). Foliar applications of paclobutrazol have been shown to control shoot growth and increase fruit size in persimmon. Similar responses to foliar applications of paclobutrazol have been reported for stonefruit. Japanese researchers found that the vegetative part of the fruit-bearing shoot was the main sink for dry matter accumulation until three weeks after pollination. After this period, the fruit became more important. Paclobutrazol can also increase dry matter partitioning to fruit, with this response doubling in non-pollinated fruit.

We suggest that control of shoot vigour may be more important in persimmon orchards without polliniser trees.

Boron also has been shown to improve persimmon pollen germination in the laboratory.

Note: Paclobutrazol is not registered for use on persimmon.

Fruit drop—vegetative growth

Fruit drop is increased by excessive shoot growth during Stage I of fruit development. The vegetative part of the fruit bearing shoot is the main sink for dry matter accumulation until three weeks after pollination. After this period the fruit becomes more important. Excessive shoot vigour may be stimulated by low crop loads, excessive nitrogen application in the early fruit development period and severe winter pruning.

Secondary growth has also been reported to promote a third wave of fruit drop.

Fruit drop—bioclimatic, soil and nutritional effects

Environmental influences can affect a range of physiological processes that can affect fruit drop.

Several Japanese studies have shown that fruit set is higher in seasons with more sunshine during and after flowering. Shading of the whole tree and calyx has been shown to reduce fruit set severely of non-pollinated or poorly pollinated flowers.

Fruit drop is also reported to be heavier on heavy alluvial soils. Increased fruit drop on these soil types may be due to waterlogging, which has been shown to increase fruit drop. Water stress has also been shown to increase the level of fruit drop, with studies in Japan showing that, at leaf water potentials greater than –1.8 MPa, fruit drop of poorly-pollinated or non-pollinated fruit increased between 5 and 15 times compared with well-pollinated fruit.

In Australia, non-pollinated fruit were found to be more susceptible to water stress. In contrast, fruit drop of well-pollinated fruit was low, even at moderate leaf water potentials (–1.8 MPa). In a controlled environment experiment in Australia, soil moisture deficits during fruit set did not affect leaf nutrients, with the exception of boron, which was reduced by 30%.

Fruit abscission may be increased by excessive nitrogen, but low nitrogen levels may be equally detrimental to fruit set. Japanese researchers found only a weak negative correlation between nitrogen concentration at harvest and fruit drop in the following season. With the cv. Wasejiro, fruit drop increased significantly with leaf nitrogen concentrations greater than 2.6% during early summer.

In contrast, for trees grown in sand culture, Japanese researchers showed that leaf nitrogen concentrations of less than 2.0% at fruit set induced severe fruit drop. The level of fruit drop was exacerbated by shading.

In Russia, nitrogen application increased fruit set and reduced flower and fruit drop.

Other nutrient factors may also influence fruit drop. Fruit drop in Chinese Luotian persimmon was associated with low phosphorus and boron soils. Sprays of 0.2% borax during the flowering period reduced the severity of drop.

Nitrogen applications in late summer and autumn have been shown to be beneficial in maintaining leaf health and in the accumulation of starch reserves for the following season's flowering and fruit set.

Yield and fruit maturity

Few studies are available on the effects of nutrition on yield. In Japan, with the cv. Nishimurawase, high rates of nitrogen (150 kg compared with 250 kg nitrogen per hectare) increased yield and average fruit weight by at least 50%. In contrast, with the cv. Tonewase, increasing rates of nitrogen per hectare from 100 to 400 kg had only small and mainly non-significant effects on yield and fruit quality. Fruit maturity was delayed by about 5 to 20% at the higher rates of nitrogen.

In Russia, a split application of nitrogen at 90 kg/ha (60% at budbreak and 40% in mid-summer) gave the highest yields. Other Japanese researchers found that nitrogen only increased yield when applied in conjunction with irrigation, with irrigation giving the greatest response. Stressing trees to below 50% field capacity reduced flowering and total yield by 30%.

Fruit quality

Japanese researchers found that increasing leaf nitrogen concentrations just before harvest reduced fruit sugar concentrations. At leaf nitrogen concentrations greater than 2.2%, fruit sugar concentrations fell by as much as 2 to 3%. They recommended that leaf nitrogen concentration be maintained below 2.1% if fruit sugar concentrations above 15% were to be achieved. They also suggested that leaf colour (L values) could be used to accurately predict leaf nitrogen concentrations.

In contrast, other Japanese researchers found that maintaining adequate, but not excessive, leaf nitrogen concentrations before and during harvesting was essential to produce fruit with high sugar concentrations. They recommended that nitrogen fertiliser be applied one month before harvest. Japanese research has also shown that in some years calyx cavity also increased with increasing nitrogen concentration at harvest, with the percentage of fruit affected by cavity increasing significantly at leaf nitrogen concentrations greater than 2.4%. Excessive nitrogen application may also depress fruit colour development.

Skin blemishes

With persimmon, most nutrients are concentrated in the seed, with the exception of calcium which is concentrated in the skin, particularly nearest the calyx. Calcium levels in the calyx are three to four times greater than in other tissues. In Japan and Korea, three types of black staining of the skin were reduced through the application of calcium carbonate and polymer and increased rates of potassium fertilising.

Shelf and storage life and disorders

Storage disorders such as skin browning or blackening were increased by orchard factors such as high soil nitrogen, overall fertility and delayed fruit maturity. Simulated cloudy conditions in Australia during the later stages of fruit development have been shown to increase fruit breakdown in storage, while mild water deficits have extended storage life.

New Zealand researchers found that as much as 80% of the total calcium content was accumulated two to three months after pollination. They concluded that an adequate supply of calcium during the early fruit period is crucial and that fruit calcium levels influence storage life.

Studies in Russia have shown that post-harvest dipping of persimmon fruit in 2% calcium chloride for three minutes has reduced storage losses from 30 to 9%. For copper, manganese and zinc, approximately 60% of the final content was acquired two to three months after pollination.

Manganese toxicity (green blotch disorder)

Green blotch is a fruit disorder associated with high manganese and low calcium levels in the fruit. It is highly correlated with high manganese and low calcium concentration 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, indicating different exclusion or tolerance mechanisms. In Japan, this disorder has been corrected by liming to increase soil pH and to decrease available soil manganese. Foliar applications of calcium carbonate during early fruit development also reduced severity.

Although we have recorded very high levels of leaf manganese (13 000 mg/kg) at a few coastal orchards in subtropical Queensland, leaf toxicity symptoms were not observed. In New Zealand, leaf manganese levels between 4000 and 5000 mg/kg have been recorded without visible toxicity symptoms. While elevated levels of manganese in the leaves may not be damaging, levels in excess of 700 mg/kg have been related to the incidence of green blotch disorder of fruit. In Queensland, we found that whole fruit had manganese levels as high as 130 mg/kg and skin of affected fruit had concentrations of around 100 mg/kg, compared with 20 mg/kg in normal fruit. Japanese researchers have set a lower limit on the desirable concentration of manganese in fruit tissue at 30 mg/kg. However, the upper limit associated with the production of quality fruit remains uncertain.

In coastal regions, persimmons should not be planted on soils with high manganese levels. In Australia, the DTPA extraction method is commonly 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 compared with 2.5 mg/kg in normal orchards.

Leaf nutrient analyses

Leaf analyses are one of most important tools for diagnosing nutrient deficiencies and establishing fertiliser recommendations for tree crops. Leaf age and position, fruiting status and phenological stage should be considered in interpreting leaf analyses. Sampling for diagnostic leaf analyses is normally conducted during the plant growth phase that corresponds to the least variation in leaf nutrient concentrations. Ideally, one sampling time can be established for all nutrients. Most interpretations of leaf analyses in tree crops are based on surveys where the ranges in nutrient concentration in high production orchards are determined. An alternative, but more laborious approach, is to develop critical leaf values giving 90% of maximum growth in pot or field experiments.

Leaf sampling procedures

Although we currently recommend taking leaf samples from non-fruiting shoots, leaf nutrient levels for both fruiting and non-fruiting samples have been found to be similar in New Zealand. However, Australian studies found significantly higher concentrations of nitrogen, potassium, calcium and zinc in leaves of shoots with pollinated fruit. It appears preferable to retain the Japanese precedent of sampling from non-fruiting shoots.

Leaf sampling times

Sampling when nutrient concentrations are relatively static is common practice. This is also the case for persimmon. In Japanese and New Zealand studies, leaf nutrients were most stable for trees sampled one to two months before harvest. In contrast, in Australian studies, we found that although the seasonal trends for nutrients generally showed larger changes during the first part of the season than in the pre-harvest period, the apparent constancy pre-harvest was undermined by the larger coefficients of variability (CVs) at that time of season. The only major exceptions were copper, iron and zinc. These nutrients are relatively unimportant in the context of leaf nutrient analysis for management purposes.

Based on these considerations, leaf sampling at fruit set may prove to be an equally effective sampling time as one month before harvest, which is the currently recommended sampling time in Japan and New Zealand. The advantage in sampling at fruit set is that, if a sub-optimum concentration is recorded, fertiliser amendments can be applied to prevent fruit quality and yield decline in the current growing season. Ideally, leaf nutrient standards need to be set at both fruit set and one month before harvest so that correct nutritional levels can be effectively monitored and optimised throughout the growing season.

Leaf nutrient standards

Leaf analysis of persimmon in not widely employed in Japan, even though basic information for using this technique has been published. The preferred tissue for assessing nutrient status is the youngest mature leaves on non-fruiting shoots, sampled approximately one to two months before harvest. Interpretation of leaf analysis in Japan is by comparison against optimum concentrations established from surveys of high-producing commercial orchards in the major production areas.

In Australian studies, leaf levels for nitrogen, phosphorus, potassium, calcium and magnesium for cv. Fuyu are in good agreement with the concentration ranges established for Fuyu persimmon in Japan. Although the Australian nutrient surveys were confined to cv. Fuyu, it is suggested that the standards set for Fuyu would be similar to those for other varieties. These studies also showed that boron concentrations were consistently higher than Japanese standards, being closer to New Zealand standards. These concentrations are still well below those associated with toxicity symptoms (390 to 500 mg/kg). Leaf nutrient standards set for fruit set in Japan are shown in Table 16 and for Australia, for the same period, in Table 14 (page 42). Leaf nutrient standards set one to two months before harvest for Japan, Korea and New Zealand are shown in Table 17.

Table 16. *Results of leaf nutrient surveys at fruit set in Fukuoka prefecture, Japan*

Nutrient	**Cultivar**	
	Fuyu	**Nishimurawase**
N (%)	2.55	2.59
P (%)	0.14	0.14
K (%)	3.10	3.48
Ca (%)	0.96	1.23
Mg (%)	0.40	0.39
Mn (mg/kg)	1211	1661

Table 17. *Australian leaf nutrient standards for non-astringent persimmon set in 1995 compared with leaf standards developed for persimmon in Japan, Korea and New Zealand*

Nutrient	**Japanese standard[1] (pre-harvest)**	**Korean[2] standard (pre-harvest)**	**New Zealand[3] (pre-harvest)**	**New Zealand[4] (December)**	**Previous Australian standard [5] (at fruit set)**
Nitrogen (%)	2.22 – 3.15	2.51	1.57 – 2.00	1.77 – 2.62	2.49 – 3.33
Phosphorus (%)	0.12 – 0.16	0.14	0.10 – 0.19	0.14 – 0.35	0.21 – 0.299
Potassium (%)	1.47 – 3.86	2.42	2.40 – 3.70	1.93 – 3.50	2.02 – 3.38
Calcium (%)	1.01 – 2.78	1.31	1.35 – 3.11	0.99 – 1.81	1.36 – 2.76
Magnesium (%)	0.22 – 0.77	0.45	0.17 – 0.46	0.24 – 0.44	0.25 – 0.41
Copper (mg/kg)	-	-	1 – 8	3 – 11	1 – 13.9
Iron (mg/kg)	-	82	56 – 124	38 – 104	63.8 – 101.4
Boron (mg/kg)	15 – 52	32	48 – 93	37 – 72	31.7 – 69.3
Zinc (mg/kg)	-	-	5 – 36	6 – 44	15.9 – 25.1
Manganese (mg/kg)	70 – 1844	-	238 – 928	78 – 147	357 – 1217

[1] Based on orchard surveys in Japan. Trees sampled about two months before harvest (Sato *et al.*, 1954; Nakamura *et al.*, 1972*b*).

[2] Korean standards, with trees sampled about two months before harvest (Kim *et al.*, 1993).

[3] Based on orchard surveys in New Zealand. Trees sampled about two months before harvest (Clark and Smith, 1990).

[4] Trees sampled in December in New Zealand.

[5] Range set by constructing 95% confidence interval about the mean for nutrient concentration data for fruit set (late October) by George *et al.*, 1995.

Fertiliser timing

Studies on the absorption of nutrients by bearing persimmon trees show that about 70 to 80% of the nitrogen, potassium, calcium and magnesium is absorbed during mid-summer (December–January). It appears that nitrogen is continuously absorbed from fruit set to just before harvest. However, most of it (60 to 70%) is absorbed from flowering to late summer. Phosphorus is absorbed in the two months before harvest.

A large quantity of potassium has accumulated in the fruit two to three months before harvest, as shown in crop loading studies (Figure 33). In contrast, root and trunk storage of potassium and magnesium occurs one to two months before harvest and during harvest. Japanese researchers found that potassium and magnesium uptake was greatest in early summer. They suggested that late winter application of these nutrients now be deferred to this period.

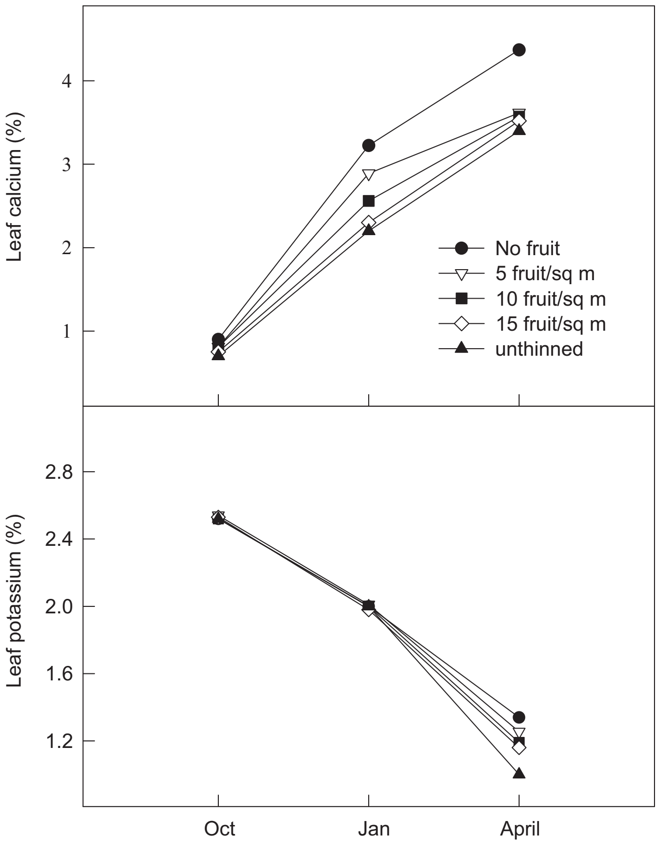


Figure 33. *Effects of crop load on leaf calcium and potassium concentrations at fruit set, end of Stage I of fruit growth and one month before harvest of the non-astringent persimmon cv. Fuyu*

Calcium absorption is greatest during spring and early summer and after mid-summer it is used for root hardening and storage for next season. In New Zealand, it was found that, for calcium, there was a significant accumulation during early fruit growth. By 12 weeks after pollination, approximately 90% of the final content had been acquired, as opposed to only 35% of the ultimate fruit dry mass. A near similar pattern was reported in Japan.

In New Zealand, it was also found that significant quantities of potassium, nitrogen and phosphorus (18 to 63% of the maximum accumulated) were remobilised from the leaves in the 12 weeks before leaf fall. This was sufficient to meet all of the potassium and nitrogen requirements and about 70% of the phosphorus requirements of the fruit during this period.

There was rarely any absorption of potassium, calcium and magnesium during or after harvest due to little or no root growth.

In Australia, we found that cv. Fuyu exhibits two peaks of root flushing about one and three months after fruit set. The time of root flushing has important implications for the timing of fertiliser application, with the ideal time to apply fertiliser being just before a peak root growth period.

Based on the above evidence, nitrogen can be applied throughout the whole growing season to achieve good uptake. The demand for potassium appears to be during the latter stages of fruit development, with higher uptake during the late summer period. Most calcium uptake is during fruit set, with applications of calcium needed before budbreak. In agreement with Japanese findings, we now recommend three times of fertilising: in spring, mid-summer and near completion of harvest.

Fertiliser rates

In Japan, the amount of fertiliser that mature trees receive varies between prefectures. In some prefectures, rates of about 113 kg nitrogen, 68 kg phosphorus and 90 kg potassium per hectare are used. In contrast, at the Gifu Agricultural Experiment Station much higher fertiliser rates were reported: 260 kg nitrogen, 210 kg phosphorus and 240 kg potassium. For field-grown cv. Maekawa Jiro, a rate of about 80 kg nitrogen per hectare produced maximum fruit size and quality. In New Zealand, the recommended rates are 125 kg nitrogen, 70 kg phosphorus, 125 kg potassium and 70 kg magnesium per hectare, with about 80% of the total fertiliser applied in the spring.

Based on the amount of nutrients removed by the fruit (Table 18), an orchard with an average yield of 20 t/ha would remove about 25 kg nitrogen, 35 kg potassium, 5 kg phosphorus, 2.5 kg calcium and 1.2 kg magnesium (Figure 34). These removal rates closely approximate the annual absorption of rates for nitrogen, phosphorus, potassium, calcium and magnesium of 100:19:142:64:10 in bearing trees and 100:17:104:49:10 in non-bearing trees in Japan.

Table 18. *Nutrient composition and removal by non-astringent persimmon cv. Fuyu and Izu at Palmwoods, Queensland, compared with nutrient removal by Fuyu fruit in New Zealand*

Nutrient	Variety and location					
	Izu[1] (Australia)		Fuyu[1] (Australia)		Fuyu (New Zealand)[2]	
	Concentration	Total nutrient removal	Concentration	Total nutrient removal	Concentration	Total nutrient removal
	(% or mg/kg)	*(g/100 kg of fresh fruit weight)*	*(% or mg/kg)*	*(g/100 kg of fresh fruit weight)*	*(% or mg/kg)*	*(g/100 kg of fresh fruit weight)*
Nitrogen	0.66	86.5	0.90	117.90	0.54	70.80
Phosphorus	0.16	20.9	0.18	23.60	0.15	19.20
Potassium	1.31	171.6	1.29	168.90	1.52	199.20
Calcium	0.11	14.4	0.10	13.10	0.11	14.40
Magnesium	0.07	9.2	0.05	6.60	0.05	6.80
Copper	10.7	0.14	3.10	0.05	2.74	0.04
Iron	24.0	0.31	18.30	0.29	24.43	0.32
Boron	20.0	0.26	17.00	0.27	7.93	0.10
Zinc	11.3	0.15	7.40	0.12	5.49	0.07
Manganese	121.6	1.59	130.00	2.09	20.61	0.27

[1] Fruit recorded 13.1% dry matter. [2] Based on studies in New Zealand (Clark and Smith, 1990b). Fruit recorded 16% dry matter.

In Russia, a split application of nitrogen at 90 kg/ha (60% at flowering and 40% after fruit set) gave the highest yield.

Table 19. *Leaching rates for selected persimmon orchards averaged for different soil types in Japan*

Nutrient	Column (kg/ha)	Lysimeter (kg/ha)
Nitrogen	40 – 60	40 – 50
Potassium	10 – 20	10 – 60
Calcium	150 – 670	150 – 250
Magnesium	50 – 90	30 – 70

The crop removal rates are three to five times lower than the lowest fertiliser rates recommended in Japan and New Zealand. Obviously, much of the applied fertiliser is lost through leaching, volatilisation and other mechanisms. Estimates for leaching losses for persimmon soil types in a major Japanese growing region are shown in Table 19.

For the nutrients nitrogen and potassium, when the leaching losses are added to the crop removal rates, they more closely approximate the lowest fertiliser rates recommended in Japan and New Zealand.

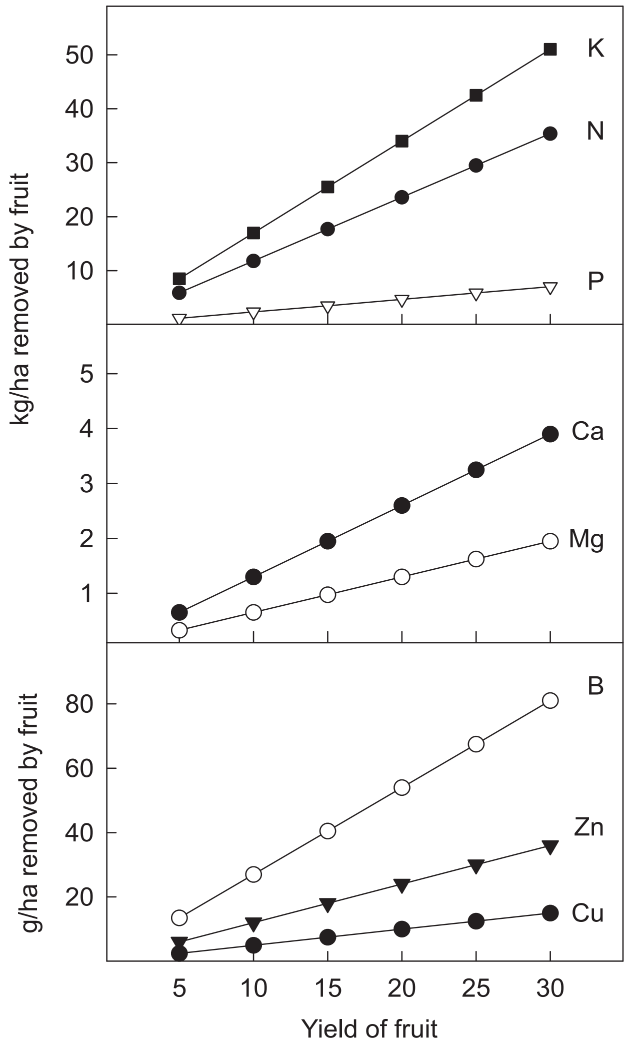


Figure 34. *Nutrient removal by different yields of fruit*

Bibliography

ALLAN, J.E., (1971). The preparation of agricultural samples for atomic absorption spectroscopy. Varion Techtron, Springvale, Victoria, pp. 6-9.

ALLAN, P., GEORGE, A.P., NISSEN, R.J., RASMUSSEN, T.S. and MORLEY-BUNKER, M.J. (1993). Effects of paclobutrazol on phenological cycling of low-chill 'Flordaprince' peach in subtropical Australia. *Scientia Horticulturae*, **53,** 73-84.

AOBA, K. (1986). Excess manganese disorder in fruit trees. *Journal of Agricultural Research Quarterly*, **20**, 38-47.

AOBA, K. and KONNO, S. (1984). Studies on the minor metal elements in orchards. X. The relationship between greenish spot disorder of Japanese fruit and excess manganese absorption. *Bulletin of Fruit Tree Research Station, A*, **11**, 55-70.

AOKI, M., TAKASE, S., KIMURA, N., KAWABUCHI, A., TANAKA, K. (1978). Studies on the percolation and adsorption of fertilisers in the soils for Kaki orchards. *Research Bulletin Aichi Research Centre*, Series B, **10**, 56 -67.

AOKI, M., TAKASE, S., KIMURA, N., KAWABUCHI, A., TANAKA, K. and OKADA, N. (1980). Effects of 4 soil types on inorganic components in leaves, yield and quality of fruits in Japanese persimmon orchards in Aichi prefecture. *Research Bulletin Aichi Research Centre*, **12**, 136-147.

AOKI, M., TANAKA, K and OKADA, N. (1977). Effects of nitrogen fertilising and ringing treatment on initial yield in 'Wasejiros' Kaki. *Research Bulletin Aichi Research Centre*, **B9**:119-130.

BALLINGER, W.E., BELL, H.K. and CHILDERS, N.F. (1966). Peach nutrition. In: *'Temperate to Tropical Fruit Nutrition'*. (Childers, N.F., Ed). Horticultural Publications: New Brunswick, U.S.A., 276-390.

BEN-AIRE, R., ZHOU, H., SONEGO, L. and ZUTKHI, Y. Plant growth regulator effects on the storage and shelf-life of Triumph persimmons. *Acta Horticulturae*, **436**, 243-250.

BERTHELOT, M.P.E. (1959). Letter to editor. *Report of Applied Chemistry*, **1**, 284.

CHALMERS, D.J., MITCHELL, P.D. and JERIE, P.H. (1984). The physiology of growth of peach and pear trees using reduced irrigation. *Acta Horticulturae,* **146**, 143-9.

CHALMERS, D.J., MITCHELL, P.D. and VAN HEEK, L. (1981). Control of peach growth and productivity by regulated water supply, tree density and summer pruning. *Journal of the American Society for Horticultural Science,* **106**, 307-12.

CHALMERS, D.J., MITCHELL, P.D. and JERIE, P.H. (1985). The relation between irrigation, growth and productivity of peach trees. *Acta Horticulturae* **173,** 283-8.

CHAPMAN H.D. and PRATT, P.F. (1961). Method of analysis for soils, plants and water. University of California Press, California, 309 pp.

CLARK, C.J. and BARRETT, L.J. (1985). Leaf analysis of persimmons: A guide to sampling and interpretation of results. *Growing Today, August*, 30-1.

CLARK, C.J. and SMITH, G.S. (1985). pH-induced manganese deficiency. Possible methods of correction. *Southern Horticulture,* 18: 21-3.

CLARK, C.J. and SMITH, G.S. (1986). Leaf analysis of persimmons. *Growing Today,* February, 15-7.

CLARK, C.J. and KAJIURA, I. (1986). Nutritional disorders of persimmon. *Growing Today*, April, 47-9.

CLARK, C.J. and SMITH, G.S. (1990a). Seasonal changes in the mineral nutrient content of persimmon leaves. *Scientia Horticulturae*, **42**, 85-97.

CLARK, C.J. and SMITH, G.S. (1990b). Seasonal changes in the composition, distribution and accumulation of mineral nutrients in persimmon fruit. *Scientia Horticulturae,* **42,** 99-111.

COLLINS, R.J., GEORGE, A.P. and MOWAT, A.D. (1993). The world trade in persimmon. *Chronica Horticulturae*, **33**, (2) 5-7.

COLLINS, R.J. and TISDELL, J.S. (1995). The influence of storage time and temperature on chilling injury in Fuyu and Suruga persimmon grown in subtropical Australia. *Postharvest Biology & Technology*, **6**, 149-157.

COLLINS, R.J. and GEORGE, A.P. (1996). Managing crop loads on non-astringent persimmon grown in the sub-tropics. *Acta Horticulturae*, **436**, 251-4.

CRESSWELL, G.C. and WICKSON, R.J. (1986). Seasonal variation in the nutrient composition of the foliage of pecan (*Carya illinoensis*). *Australian Journal of Experimental Agriculture*, **26**, 393-7.

DANN, I.R., WILDES, R.A. and CHALMERS, D.J. (1984). Effects of limb girdling on growth and development of competing fruit and vegetative tissues of peach trees. *Australian Journal of Plant Physiology*, **11**, 49-58.

DE JONG, T.M. (1986). Fruit effects on photosynthesis in *Prunus persica*. *Plant Physiology*, **66**, 149-53.

DE VILLIERS, H., CUTTING, J.G., JACOBS, G. and STRYDOM, D.K. (1990). The effect of girdling on fruit growth and internal quality of ‘Culemborg’ peach. *Journal of Horticultural Science*, **62**, 151-5.

DEJONG, T.M. (1982). Leaf nitrogen content and CO_2 assimilation capacity in peach. *Journal of the American Society for Horticultural Science*, **107**, 955-9.

DEJONG, T.M. (1983). CO_2 assimilation characteristics of five *Prunus* tree fruit species. *Journal of the American Society for Horticultural Science,* **108**, 303-9.

DEJONG, T.M. and DOYLE, J.F. (1984). Leaf gas exchange and growth responses of mature ‘Fantasia’ nectarine trees to paclobutrazol. *Journal of the American Society for Horticultural Science*, **109**, 878-82.

EARLY, J.D. Jr and MARTIN, G.C. (1988). Sensitivity of peach seedling vegetative growth to paclobutrazol. *Journal of the American Society for Horticultural Science,* **113**, 23-7.

EREZ, A. (1984). Dwarfing peaches by pruning and paclobutrazol. *Acta Horticulturae*, **146**, 235-8.

EREZ, A. (1984). Effect of soil-applied paclobutrazol in drip irrigated peach orchards. *Acta Horticulturae*, **179**, 513-20.

EVANS, E.P. (1977). Pruning and crop control of peach trees. Department of Agricultural Services, Pretoria, South Africa. Technical Publication B.I., 1-7.

FERNANDEZ-ESCOBAR, R., MARTIN, R., LOPEZ-RIVARES, P. and PAZ SUAREZ, M. (1987). Girdling as a means of increasing fruit size and earliness in peach and nectarine cultivars. *Journal of Horticultural Science*, **62**, 463-7.

FLORE, J.A. and GUCCI, R. (1988). L’influenza dell’atttivita’ dei centri di richiamo per gli assimilati sulla fotosintesi deglialberi da frutto. *Frutticoltura*, **4**, 63-8.

FLORE, J.A. and LAKSO, A.N. (1989). Environmental and physiological regulation of photosynthesis in fruit crops. *Horticultural Reviews*, **11**, 111-57.

FUKUI, H., HIRATA, K. and NAKAMURA, M. (1995). Phosphorus uptake of root restricted cultured Japanese persimmon trees. *Journal of the Japanese Society for Horticultural Science*, **64**, (Suppl.2), 190-91.

FUKUI, H., MOCHIZUKI, K. and NAKAMURA, M. (1993). Nutrient uptake of micropropagated Japanese persimmon cv. Nishimurawase (three-year-old). *Journal of the Japanese Society for Horticultural Science*, **62**, (Suppl.2), 190-1.

FUKUI, H., SUZUKI, Y., HORIBE, T. and GOTO, M. (1997). Potassium, calcium and magnesium uptake of Japanese persimmon trees in root restricted culture. Proceedings of the First International Persimmon Symposium, *Acta Horticulturae*, **436**, 285-295.

FUKUI, H., SUZUKI, Y., OGAWA, E., HIRATA, K., MATSUBARA, Y. and NAKAMURA, M. (1999). Nitrogen uptake by three- to four-year-old potted trees of Japanese persimmon cv. Nishimurawase. *Journal of the Japanese Society for Horticultural Science*, **68**, 578-584.

FUKUI, H., UMEDA, H., MOCHIZUKI, K. and NAKAMURA, M. (1994). Relationship between cell division in root tips of Japanese persimmon (cv.

Nishimurawase) and soil temperature. *Journal of the Japanese Society for Horticultural Science*, **63**,291-7.

FUKUYO, K. (1980). Causes and control of black stain of persimmon fruit in Japan. *Bulletin of the Shizuoka Prefectural Citrus Experiment Station*, **16**, 29-38.

FUMURO, M. (1998). Effects of trunk girdling during early shoot elongation period on tree growth, mineral absorption, water stress and root respiration in Japanese persimmon cv. Nishimurawase. *Journal of the Japanese Society for Horticultural Science*, **67**, 219-227.

GAINES, T.P. and MITCHELL, G.A. (1979). Boron determination in plant tissue by the azomethine H method. *Communications in Soil Science and Plant Analyses*, **10**, 1099-108.

GANG-BANGCHU, WANG, JINFENG, GANG, B.C. and WANG, J.F. (1997). Study on pollination biology of persimmon trees. *Forest Research*, **10**, 237-243. Research Institute of Subtropical Forestry, CAF, Fuyang, Zhejiasng, China.

GASANOV, Z.M. (1984). Nitrogen nutrition and productivity of persimmon. *Sadovodstvo*, 12, 37. (Russian).

GEORGE, A.P. and NISSEN, R.J. (1987). Growth control of low-chill stonefruit using growth retardants and other management techniques. In: *'Proceedings of the First National Stonefruit Conference'*. (Skinner, I., Ed) Exotic Fruit Growers Association, Lismore, Australia, 132-43.

GEORGE, A.P., NISSEN, R.J., LLOYD, F. and RICHENS, K. (1988). Factors affecting fruit quality of low-chill stonefruit in subtropical Australia. *Acta Horticulturae,* **270**, 559-71.

GEORGE, A.P. and NISSEN, R.J. (1988). Effects of paclobutrazol on vegetative and floral development of Fla 6-3 and Sunred nectarines. *Acta Horticulturae*, **189**, 45-51.

GEORGE, A.P. and NISSEN, R.J. (1992). Effects of water stress, nitrogen and paclobutrazol on flowering, yield and fruit quality of the low chill peach cultivar Flordaprince. *Scientia Horticulturae*, **49**, 197-209.

GEORGE, A.P., NISSEN, R.J., MORLEY-BUNKER, M.J. and COLLINS, R.J. (1993). Effects of pollination and irradiance on fruiting of persimmon (*Diospyros kaki* L.) in subtropical Australia. *Journal of Horticultural Science*, **68**, 447-54.

GEORGE, A.P., NISSEN, R.J. and COLLINS, R.J. (1993). Effects of temperature and pollination on growth, flowering and fruit set of the non-astringent persimmon cultivar 'Fuyu' under controlled temperatures. *Journal of Horticultural Science*, **69**, 225-30.

GEORGE, A.P., NISSEN, R.J. and RASSMUSSEN, T.S. (1993). Effects of post-harvest topping, autumn cincturing and paclobutrazol on growth, yield and fruit quality of the low chill nectarine cv. Sundowner in subtropical Australia. *Australian Journal of Experimental Agriculture,* **33**, 353-62.

GEORGE, A.P., COLLINS, R.J. and RASMUSSEN, T.S. (1994). Phenological cycling of non-astringent persimmon in subtropical Australia. *Journal of Horticultural Science*, **69**, 937-46.

GEORGE, A.P., COLLINS, R.J. and NISSEN, R.J. (1994). Growth, yield and fruit quality of non-astringent persimmon in subtropical Australia. *Australian Journal of Experimental Agriculture*, **34,** 267-75.

GEORGE, A.P., NISSEN, R.J., COLLINS, R.J. and RASMUSSEN, T.S., (1995). Effects of fruit thinning, pollination and paclobutrazol on fruit set and size of persimmon (*Diospyros kaki* L.) in subtropical Australia. *Journal of Horticultural Science*, **70**, 477-484.

GEORGE, A.P., NISSEN, R.J. and COLLINS, R.J. (1995). Seasonal leaf nutrient patterns and standard leaf nutrient levels for non-astringent persimmon in subtropical Australia. *Journal of Horticultural Science*, **70**, 807-16.

HASEGAWA, K. and NAKAJIMA, Y. (1990). Effects of flowering date, seediness, GA treatment and location of fruits in the foliar canopy on the fruit quality of persimmon (*Diospyros kaki* L.). *Journal of the Japanese Society for Horticultural Science*, **59**, 263-70.

HIRATA, N. and KUROOKA, H. (1974). Physiological studies of developing and ripening fruits of the Japanese persimmon. 1. The effects of degrees or times of artificial defoliation during last fall on carbohydrate contents in shoot, fruit growth and fruit quality. *Bulletin of the Faculty of Agriculture, Tottori University*, **26**, 1-14.

IIMURO, S., OKAMURA, T, SAWAMURA, Y., MATSUMOTO,Y. and FUKUNAGA, S. (1974). Studies on the tree nutrition to sugar content of persimmon's fruits. I. *Bulletin of the Nara Agricultural Experiment Station*, **6**, 9-15.

IIMURO, S., ONO, Y., SUGIMOTO, Y., FUKUNAGA, S. and KURODA, K. (1980). Studies on the green spot disorder of Japanese persimmon (Matsumotowase Fuyu). *Bulletin of the Nara Agricultural Experiment Station*, **11,** 1-13.

JONES, W.W. and EMBLETON, T.W. (1968). The influence of amount of fruit and time of harvest on macronutrient concentration in 'Valencia' orange leaves. *Journal of the American Society for Horticultural Science*, **92**, 191-4.

KADOSIGE K., KUROYANAGI, N. and KONOMI, K. (1990). Diagnosis of nutrient condition of kaki tree (1) Field survey in producing district. *Bulletin of Fukuoka Agricultural Research Centre*, Cent **B-10**, 73-6.

KAJIURA, I. (1980). Kaki culture in Japan. *The Orchardist of New Zealand*. April 1980, 98-101.

KATO, M., KATO, T., IMAGAWA, H., KOUMURA, H., IWASE, H. and HAYASHI, G. (1993). The effect of soil condition and amount of supplied fertiliser on fruit quality and yield of Japanese persimmon (*Diospyros kaki*) Thunb. cv. Nishimurawase. *Research Bulletin of Aichi Agricultural Research Centre*, **25**, 267-273.

KENWORTHY, A.L., (1961). Interpreting the balance of nutrient elements in leaves of fruit trees. In: *Plant Analysis and Fertiliser Problems*. (Reuther, W., Ed). American Institute of Biological Science, Washington, DC, 28-43.

KIM, M. S., LEE, H.C., KIM, J.H., SONG, N.H., KIM, M.J., SHIN, K.C. (1993). Studies on the nutritional diagnosis of non-astringent persimmon (*Diospyros kaki* Thunb.) cv. Fuyu. *RDA Journal of Agricultural Science*, **35**, 311-320.

KISHIMOTO, O. (1963). Studies on the standard of fruit thinning in Japanese persimmon. *Journal of the Japanese Society for Horticultural Science*, **32** (3), 20-6.

KISHIMOTO, O. (1964). Factors affecting fruit weight of Japanese persimmon (*Diospyros kaki* L.). *Journal of the Japanese Society for Horticultural Science*, **33** (4), 31-7.

KISHIMOTO, O. (1975). Estimations of optimum range of degree of fruit thinning and desirable fruit weight in Japanese pear and persimmon tree. *Journal of the Japanese Society for Horticultural Science*, **43** (4), 368-76.

KITAGAWA, H. and GLUCINA, P.G. (1984). Persimmon culture in New Zealand. New Zealand Department of Scientific and Industrial Research Information Series No. 159. Science Information Publishing Centre, Wellington, New Zealand, 74 pp.

KITAJIMA, A., FUJIWARA, T., KUKIZAKI, T., ISHIDA, M. and SOBAJIMA, Y. (1987). Relationship between early fruit drop and dry matter accumulation on bearing shoot in Japanese persimmon (*Diospyros kaki* Thunb.) *Scientific Reports of the Kyoto Prefectural University, Agriculture,* **39**, 1-11.

KITAJIMA, A., MATSUMOTO, T., ISHIDA, M. and SOBAJIMA, Y. (1990). Relationship between dry matter production of bearing shoots and physiological fruit drop of Japanese persimmon by shading treatments. *Journal of the Japanese Society for Horticultural Science*, **59**, 75-81.

KOO, R.C. and YOUNG, T.W. (1977). Effects of age, position and fruiting status on mineral composition of 'Tonnage' avocado leaves. *Journal of the American Society for Horticultural Science*, **102**, 311-3.

LEE, S.K., SHIN, I.S. and PARK, Y.M. (1993). Factors involved in skin browning of non-astringent cv. Fuyu persimmon. *Acta Horticulturae*, **343**, 300-3.

LEECE, D.R. (1975a). Diagnostic leaf analyses for stonefruit. 4. Plum. *Australian Journal of Experimental Agriculture and Animal Husbandry*, **15**, 112-7.

LEECE, D.R. (1975b). Diagnostic leaf analyses for stonefruit. 5. Sweet cherry. *Australian Journal of Experimental Agriculture and Animal Husbandry*, **15**, 118-22.

LEECE, D.R. and GILMORE, A.R. (1974). Diagnostic leaf analyses for stonefruit. 2. Seasonal changes in the leaf composition of peach. *Australian Journal of Experimental Agriculture and Animal Husbandry*, **14**, 822-7.

LEECE, D.R., (1968). The concept of leaf analyses for fruit trees. *Journal of the Australian Institute of Agricultural Science*, **34**, 146-53.

LEUTY, S.J. and PREE, D.J. (1980). The influence of tree population and summer pruning on productivity, growth and quality of peaches. *Journal of the American Society for Horticultural Science*, **105**, 702-5.

LI, S.H., BUSSI, C., CLANET. H. and REGNARD, J.L. (1989). Response of peach trees to paclobutrazol; product effects on vegetative growth and cropping. *Fruits,* **44**, 99-108.

LIU, Y.J. and WANG, W.J. (1989). Seasonal changes in the contents of major nutrient elements and fruits of persimmon trees. *Acta Horticulturae Sinica,* **16**, 109-113.

LIU-YONG, HUOGUANGHUA, LIU-SHANJUN, XIAO-DEXING, LUO-LAISHUI, LIU-Y, HUO, G.H., LIU, S.J., XIAO, D.X. and LUO, L.S. (2000). A study on the growth and leaf physiological and biochemical characteristics of 'Fuyu' persimmon grafted with some rootstocks. *Acta Agriculturae-Universitatis-Jiangxiensis*, **22**, 54-7.

MARINI, R.P. (1986). Growth and cropping of 'Redhaven' peach trees following foliar applications of flurprimidol and paclobutrazol. *Journal of the American Society for Horticultural Science,* **111**, 849-53.

MARINI, R.P. (1987). Growth and cropping of 'Redhaven' peach trees following soil application of paclobutrazol. *Journal of the American Society for Horticultural Science*, **112**, 18-21.

MARTIN, G.C., YOSHIKAWA, F. and LA RUE, J.H. (1987). Effect of soil applications of paclobutrazol on vegetative growth, pruning time, flowering, yield and quality of 'Flavorcrest' peach. *Journal of the American Society for Horticultural Science*, **112**, 915-21.

MATSUMOTO, Y. and KURODA, K. (1982). Studies on bud and fruit thinning of Japanese persimmon. The establishment of the standard of thinning to obtain large cv. Fuyu fruits. *Bulletin of the Nara Agricultural Experiment Station*, **13,** 9-20.

MATSUMURA, H. (1999). Container planting cultivation of Japanese persimmon. (Part 3). Improvement of the fruit quality by fertilisation and irrigation. *Journal of Society of High Technology in Agriculture*, **11**, 259-266.

McKENZIE, M.A. and WALLACE, H.S., (1954). The Kjeldahl determination of nitrogen; a critical study of digestion conditions. Temperature, catalyst and oxidising agent. *Australian Journal of Chemistry*, **7,** 55-70.

MENZEL, C.M., CARSELDINE, M.L., HAYDON, G.F. and SIMPSON, D.R. (1992). A review of existing and proposed new leaf nutrient standards for lychee. *Scientia Horticulturae*, **49**, 33-53.

MOWAT, A.D., GEORGE, A.P. and COLLINS, R.J. (1996). Macro-climate effect on fruit development and maturity of non-astringent persimmon cv. Fuyu. Proceedings of the First International Persimmon Symposium. *Acta Horticulturae*, **436**, 195-203.

NAGASAWA, K., TAKAHASHI, E. and NOZAKI, M. (1968). Physiological studies on fruit drop of *Diospyros kaki.* Effects of gibberellin sprays on fruit drop prevention in Hiratanenashi and Fuyu varieties. *Technical Bulletin of Faculty of Horticulture, Chiba*, **16**, 9-16.

NAKAMURA, N., KAWASE, I., GOTO, Y., KANI, N. and HISAMATSU, S. (1972a). A survey on the nutritional status of persimmon orchards in Gifu city area. 1. Selection of orchards for survey and results of first year determination. *Research Bulletin of the Faculty of Agriculture, Gifu University*, **33**, 25-36.

NAKAMURA, N., KAWASE, I., MATSUURA, K., KANI, N. and OKAZAKI, A. (1972b). A survey on the nutritional status of persimmon orchards in Gifu city area. 2. The results of second and third year determinations and conclusion based on three years survey. *Research Bulletin of the Faculty of Agriculture, Gifu University*, **33**, 37-49.

NII, N. (1993). Fruiting effects on leaf characteristics, photosynthesis and root growth in peach trees. *Journal of the Japanese Society for Horticultural Science,* **62**, 519-26.

NOEL, A.R.A. (1970). The girdled tree. *Botanical Review,* **36**, 162-95.

OBERLY, G.H. and BOYNTON, C. (1966). Apple nutrition. In '*Temperate to Tropical Fruit Nutrition'*. (Childers, N.F., Ed). Horticultural Publications: New Brunswick, U.S.A., 1-50.

ONO, Y. and KURODA, K. (1986). Studies on the index of diagnosis of nutrient condition in order to predict high fruit quality fruits and easy speedy diagnosis of leaf colour in Japanese persimmon trees. *Bulletin of Nara Agricultural Experimental Station*, **17**, 11-18.

OOSHIRO, A. and ANMA, S. (1998). Relationship between the number of flowers and the nutrient status of Japanese persimmon tree cv. 'Maekawa Jiro'. *Journal of the Japanese Society for Horticultural Science*, **67**, 890-896.

POPENOE, J. and SCOTT, L.E. (1956). Some effects of potassium nutrition and fruit load on the peach as indicated by foliar analysis. *Proceedings of the American Society for Horticultural Science*, **68**, 56-62.

PROEBSTING, E.L. Jr., CARTER, G.H., INGALSBE, D.W. and NEUBERT, A.M. (1957). Relationship between leaf nitrogen and canning quality of 'Elberta' peaches. *Proceedings of the American Society for Horticultural Science*, **69**, 131-9.

QUINLAN, J.D. (1980). Recent developments in the chemical control of tree growth. *Acta Horticulturae*, **114**, 144-51.

RASMUSSEN, T.S. and HENRY, R.J. (1990). Starch determination in horticultural plant material by an enzymic-colorimetric procedure. *Journal of Food and Agricultural Science*, **52**, 159-70.

RASMUSSEN, T.S. and HENRY, R.J., (1990). Starch determination in horticultural plant material by enzymic-colorimetric procedure. *Journal of Food and Agricultural Science*, **52**, 159-70.

ROBINSON, J.B. (1986). Fruits, vines and nuts. In: *Plant Analysis, An Interpretation Manual*. (Reuter, D.J. and Robinson, J.B., Eds). Inkata Press, Sydney, 120-47.

ROM, R.C. (1988). Progress in peach rootstock. In *'The Peach'*. (Childers, N.F. and Sherman, W.B., Eds). Horticultural Publications: Gainesville, Florida, 302-8.

ROPER, T.R., KELLER, J.D., LOESCHER, W.H. and ROM, C.R. (1988). Photosynthesis and carbohydrate partitioning in sweet cherry: fruiting effects. *Plant Physiology*, **72**, 42-47.

SANEWSKI, G.M. (1992). Green blotch disorder of persimmon. In: *Maroochy Horticultural Research Report No 6.* (Whiley, A.W., Ed). Research Establishments Publication, Department of Primary Industries, Queensland Australia, 93-4.

SATO, K., ISHIHARA, M. and HARADA, R., (1954). Studies on leaf analyses of fruit trees. 6. Leaf analysis in Japanese persimmon orchards. *Bulletin of the National Institute of Agricultural Science*, Series E., **3**, 169-86.

SATO, K., ISHIHARA, M. and WAKABAYASHI, S., (1952). Studies on leaf analysis of fruit trees. 1. Fundamental studies on leaf analysis. *Bulletin of the National Institute of Agricultural Science*, Series E., **1**, 1-28.

SAWAMURA, Y., NISHINO, S., ONO, Y. and MAE, E. (1993). Relationship between storage quality of Japanese persimmon fruits 'Fuyu' and cultivated conditions. *Bulletin of the Nara Agricultural Experiment Station*, **24**, 64-5.

SHEAR, C.B. and FAUST, M. (1980). Nutritional ranges in deciduous fruits and nuts. *Horticultural Review*, **2**, 146-63.

SIO, J., BOIXADERA, J., ROSERA, J., MICHALCZUK, L. (1999). Effects of orchard factors and mineral nutrition on bitter pit in Golden delicious apples. Proceedings of the International Symposium on Effect of Pre-harvest and Post-harvest Factors on Storage of Fruit. *Acta Horticulturae*, **485**, 331-4.

SHERMAN, W.B., (1987). The low-chill peach improvement program: why, how, where. In *'Proceedings of the First National Low-chill Stonefruit Conference'*. (Skinner, I., Ed) Exotic Fruit Growers Association, Lismore, Australia, 16-8.

SMITH, F.W. (1986). Interpretation of plant analysis: concepts and principles. In *'Plant Analysis. An Interpretation Manual'* (Reuter D.J. and Robinson, J.B., Eds) Inkata Press, Australia, 1-12.

SMITH, P.F., (1962). Mineral analysis of plant tissues. *Annual Review of Plant Physiology*, **13**, 81-108.

SPARKS, D. (1977). Effects of fruiting on scorch, premature defoliation and nutrient status of 'Chicksaw' pecan leaves. *Journal of the American Society for Horticultural Science*, **102**, 669-73.

STEFFENS, G.L., WANG, S.Y., FAUST, M. and BYUN, J.K. (1985). Growth, carbohydrate and mineral element status of shoot and spur leaves and fruit of 'Spartan' apple trees treated with paclobutrazol. *Journal of the American Society for Horticultural Science*, **110**, 850-5.

STILES, W.C. (1984). Effects of pruning on growth and size of trees. *Acta Horticulturae,* **146**, 97-104.

STINCHCOMBE, G.R., COPRAS, E., WILLIAMS, R.R. and ARNOLD, G. (1984). The effects of paclobutrazol and daminozide on the growth and yield of cider apple trees. *Journal of Horticultural Science,* **59**, 323-7.

SUZUKI, K., TOSHIHIHIKO, Y., MURASE, S., MIYAGAWA, H., NOGATA, T., MITOBE, M. and MORITA, A. (1981). Colour charts: Useful guide to evaluate fruit maturity. III. Fruit skin colour in relation to fruit maturity. *Bulletin of the Fruit Tree Research Station*, Ministry of Agriculture, Forestry and Fisheries Series A, No. **8**. pp. 99-100.

SUZUKI, A., AOBA, K., MURAKAMI, Y. and MAOTANI, T. (1989). Effects of nitrogen nutrition on physiological fruit drop of Japanese persimmon. *Bulletin of the Fruit Tree Research Station, A, Ibaraki*, **16**, 39-45.

SUZUKI, A., MURAKAMI, Y. and MAOTANI, T. (1988). Physiological studies on physiological fruit drop of persimmon. *Bulletin of the Fruit Tree Research Station, Yatabe*, **15**, 41-9.

TANAKA, K and SUZUKI, T. (1966). Studies on manganese deficiency in Japanese persimmons (*Diospyros kaki* L.). *Bulletin of the Aichi Horticultural Experimental Station*, **4**, 31-41.

TANAKA, K., AOKI, M., HIROTA, K., KAWABUCHI, A. and SINODA, H. (1966). Magnesium deficiency in Japanese persimmon. I. Influences of foliar sprays of magnesium salts and the mineral composition of leaves, fruits and shoots. *Research Bulletin of Aichi-ken Agricultural Research Centre, Series **B**,* **5**, 19-35.

TANAKA, K. and AOKI, M. (1971). Effects of irrigation and nitrogen fertiliser application in summer on the fruiting of 'Fuyu' kaki (*Diospyros kaki* L.), *Research Bulletin of the Aichi-Ken Agricultural Research Centre,* Series b, **3**, 9-18.

TANAKA, K., AOKI, M., KINBARA, T., TSUDA, K. and KAWABUCHI, A.(1976). Studies on the absorption of essential elements by kaki in water culture. *Research Bulletin of Aichi-ken Agricultural Research Centre, Series **B**,* **8**:74-84.

TAYLOR, B.K. and VAN DEN ENDE, B. (1970). The nitrogen nutrition of the peach tree. *Australian Journal of Experimental Agriculture and Animal Husbandry*, **10**, 214-7.

TERBLANCHE, J.H. and STRYDOM, D.K. (1973). Effects of autumn nitrogen and nutrition, urea sprays and a winter rest-breaking spray on budbreak and blossoming of young 'Golden Delicious' trees grown in sand culture. *Deciduous Fruit Grower,* **23**, 8-14.

TERBLANCHE, P.J.C., HESEBECK, I. and STRYDOM, D.K. (1979). Effects on autumn nitrogen nutrition and a winter rest-breaking spray on the growth, development and chemical composition of young 'Golden Delicious' apple trees grown in sand culture. *Scientia Horticulturae,* **10**, 37-48.

TREGLAZOVA, N.V. AND AZERBAIDZHAN, S.R. (1989). Pre-storage treatment of persimmon fruit with calcium chloride. *Subtropicheskie Kul'tury*, **6**, 108-111.

TSUMITA, M., WATANABE, T., KOTO, M, (1968). The amounts of the nutrient elements absorbed by Japanese persimmon trees. *Bulletin of Kanagawa Horticultural Experiment Station*, **16**, 38-45.

TUKEY, L.D. (1964). *Dwarfed Fruit Trees*. Macmillan, New York.

VAYSSE, P., BORIN, M. and SATTIN, M. (1994). Apple quality: improving the fruit calcium content. *Proceedings of the Third Congress of the European Society for Agronomy*, Padova University, Abano-Padova, Italy, 624-5.

WALSH, C.S., ALLNUTT, F.J., MILLER, A.N. and THOMPSON, A.H. (1989). Nitrogen level and time of mechanised summer shearing influence long-term performance of a high-density 'Redskin' peach orchard. *Journal of the American Society for Horticultural Science*, **114**, 373-7.

WANAKA, M., KOMATSU, H. and YAMAMOTO, T. (1998). Effect of nitrogen fertiliser on Japanese 'Tonewase' persimmon. (no reference).

WILLIAMS, M.W. (1984). Use of bioregulators to control vegetative growth of fruit trees and improve fruiting efficiency. *Acta Horticulturae,* **146**, 97-104.

WILLIAMS, M.W. and EDGERTON, L.F. (1983). Vegetative growth control of apple and pear trees with ICI P333 (paclobutrazol), a chemical analog of Bayleton. *Acta Horticulturae,* **137**, 111-6.

XU-HAI, ZHANG-LITIAN, ZHOU-JIANSHE, XU-YH, ZHANG-JS. (2000). The causes of unusual fruit drop of Luotian persimmon and its control. *South China Fruits*, **29**, 1, 37.

YAMADA, M., KURIHARA, A. and SUMI, T. (1987). Varietal differences in fruit bearing in Japanese persimmon (*Diospyros kaki* Thunb.) and their yearly fluctuations. *Journal of the Japanese Society for Horticultural Science*, **56**, 293-9.

YAMAMOTO, T., SATOH, Y., FUNYUH, T., ISHIJIMO, Y., SUZUKI, K. (1993). Estimated canopy net photosynthetic rates and their relation to fruit production in Japanese persimmon Hiratanenashi. *Journal of the Japanese Society for Horticultural Science*, **62**, 27-39.

YAMAMURA, H., MATSUI, K. and MATSUMOTO, T. (1989). Effects of gibberellins on fruit set and flower bud formation in unpollinated persimmons (*Diospyros kaki*). *Scientia Horticulturae*, **38**, 77-86.

YOUNG, M.J. and CROCKER, T.E. (1982). Severe post-harvest topping of high density peaches and nectarines. *HortScience,* **17**, 220.

ZUNDE, M., ALEXANDER, A. and LUDDERS, P. (1997). Influence of summer boron sprays on storability in apple cv. Elstar. *Erwerbsobstbau,* **39,** 62-4.

Appendix A: *soil analysis units*

When expressing results of a soil analysis, it is not sufficient to use qualitative terms like low, medium, high, acid, basic, neutral, good or poor. Just as time is measured in seconds, distance in metres and mass in grams, the various quantities measured in soil analysis have standard units by which they are expressed. The following descriptions should help in understanding some of the terms used.

Units used to express soil analysis results

%, percentage, percent

This is a measure of the concentration of a constituent in the total material. One percent is one part of the constituent measured per hundred (100) parts of the material analysed.

For example, 1.0% organic carbon is 1 g of organic carbon in 100 g of air dry soil.

mg/kg, mg kg^{-1}, µg/g, µg g^{-1}, ppm, parts per million

This is another measure of concentration. One mg/kg is one milligram of the nutrient per kilogram of soil. For most scientific journals, this unit is printed as mg kg^{-1}.

For example, 22 mg/kg for phosphorus is equivalent to 22 mg of phosphorus extracted by the sodium bicarbonate test per kilogram of air dry soil.

Note: mg/kg and % are related as follows:

- 1 mg/kg = 0.0001% or
- 1 % = 10 000 mg/kg.

meq/100 g or meq %, milliequivalents percent

The term milliequivalents per 100 g of soil is used to express the concentration of the cations calcium (Ca), magnesium (Mg), potassium (K), sodium (Na) and aluminium (Al) in the soil.

Milliequivalents (or milligram equivalents) refers to the number of milligrams of an element which will combine with or replace 1 milligram of hydrogen. Milliequivalents percent means the number of milligram equivalents of an element per 100 g of the substance.

An alternative expression to meq/100 g is centimole charge of specific ion (i+)/kilogram, abbreviated to cmol(i +)kg^{-1}. This unit is now commonly used in scientific papers, but the value is the same as for meq/100 g.

To convert the results expressed as meq/100 g to ppm, multiply by 10 times the equivalent weight of the ion:

- ppm = meq/100 g x equivalent weight x 10.

Equivalent weights of some nutrients are:

H^+ = 1.0, O = 8.0, Mg^{++} = 12.1, Ca^{++} = 20.0, Na^+ = 23.0, K^+ = 39.1, AI^{+++} 89.9, Cl = 35.5, N03 = 62.0, $NH4^+$ = 18.0

Examples

- Where K = 0.58 meq/100 g, then K concentration in ppm becomes 0.58 x 391 = 227ppm.
- Where Mg = 3.6 meq/100 g, the Mg concentration in ppm becomes 3.6 x 121 = 436 ppm.

dS/m, deciSiemens/metre

The term commonly used now for electrical conductivity (EC) is deciSiemens/metre, dS/m or dSm^{-1}. The term formerly used was milliSiemens/centimetre, but the values are the same. This term is an electrical unit used to express the ability of the soil solution to conduct an electrical current. It is known as the electrical conductivity of the solution between two electrodes, 1 cm apart. As the soluble elements in a soil are either positively or negatively charged particles (ions), they have the ability to conduct an electric current. The higher the concentration of ions in solution, the greater is this ability and the higher is the conductivity. For more information, refer to *Salinity*.

At the time of writing there was no general agreement on the best unit(s) to use in Australia. The Système International (SI) unit is milliSiemens/centimetre. The commonly used units and their conversions are:

- deciSiemens per metre (dS/m);
- milliSiemens per centimetre (mS/cm);
- microSiemens per centimetre (µS/cm);
- 1 dS/m = 1 mS/cm = 1000 µS/cm;
- 1 µS/cm = 0.001 dS/m.

pH

The pH measurement has no units. It is defined as the negative logarithm of the hydrogen ion concentration of a solution. It has a range of 1.0 to 14.0. Pure water is neutral (i.e. pH = 7.0). Below 7.0, the solution is acidic; above 7.0 it is alkaline.

kg/ha, kilograms per hectare

This term (or in imperial units, lb/ac or pounds per acre) is used particularly in the USA and can quickly be related to fertiliser applications. However, it presupposes that the weight of a hectare of soil to a specific depth is known, but usually it is not. The bulk density of the soil is required and this value differs for each soil type and horizon, depending on the volume of air spaces, the mineral constituents and organic matter content.

Appendix B: *water analysis units*

The salinity of water is given either by the amount of salts dissolved in it—total soluble salts or *total dissolved solids* (TDS)—or by its ability to conduct electricity—its *electrical conductivity (EC).* Increasing total dissolved solids gives increasing electrical conductivity. The term *electrolytic conductivity* is also used, but as both are shortened to EC, the difference in name is minor.

Units used to express water analysis results

The units used for TDS are:

- parts per million (ppm)
- milligrams per litre (mg/L)
- 1 ppm = 1 mg/L.

The formulae for converting EC to TDS and vice-versa are:

- EC (in µS/cm) x 0.64 = TDS (in ppm)
- TDS (in ppm) is approximately 2/3 EC (in µS/cm).

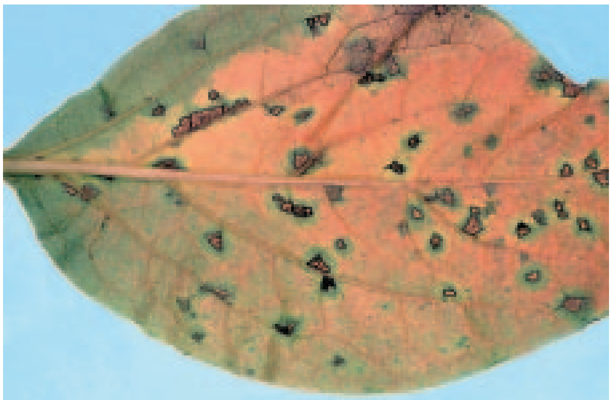
These conversions are only approximate. The actual formula depends on the types of salts present.

Example

A water has an EC of 700 µS/cm. TDS in this water will be about 700 x 2/3 = about 470 ppm.

Deficiency and toxicity *symptoms*

Spots or marks on leaves



Cercospora leaf spot disease

Cause: The fungus *Pseudocercospora* sp.

Identification notes: Small, dark brown spots on both leaf surfaces. The spots are limited by the veins and so become angular in shape. Severely affected leaves fall readily. Upper: field symptom. Lower: close-up of affected leaves.

Treatment and prevention: Once significant leaf spot symptoms are evident, it is generally too late to apply treatments. However, spraying with an appropriate chemical will help prevent build-up of the fungus. In future seasons, apply four protective sprays two weeks apart, starting when half of the flowers are open. Spraying the prunings and the leaf litter under the tree in winter helps to prevent carry over of the disease from one season to the next.

Manganese toxicity

Cause: High uptake of manganese from the soil. Occurs in soils with high manganese levels when pH falls below 6.5 (1:5 water test).

Identification notes: Affected leaves have an irregular pale yellow margin with many small dark spots on the leaf surface.

Treatment and prevention: Get a leaf analysis done to confirm the diagnosis. Apply lime or dolomite to raise soil pH to 6.5 (1:5 water test). In future, do regular leaf and soil analyses to monitor nutrient levels. In high manganese soils, maintain soil pH at 6.5 or above (1:5 water test).

Yellow leaves

Nitrogen deficiency

Cause: Insufficient nitrogen available to the tree.

Identification notes: The older leaves are generally affected, becoming small, narrow, pale green and often with slight inward rolling.

Treatment and prevention: Get a leaf analysis done to confirm the diagnosis. Adjust the fertiliser program according to the leaf analysis results. In future, do regular leaf and soil analyses to monitor nutrient levels. Apply appropriate amounts of nitrogen fertiliser throughout the growing season.

Yellow leaves

Potassium deficiency

Cause: Insufficient potassium available to the tree. Generally caused by an imbalance of potassium, calcium and magnesium in the soil.

Identification notes: Yellowing begins at the margin of the leaf and spreads towards the veins. Brown spots develop within affected areas. Upper: field symptom. Lower: close-up of affected leaves.

Treatment and prevention: Get a leaf analysis done to confirm the diagnosis. Adjust the fertiliser program according to the leaf analysis results. In future, do regular leaf and soil analyses to monitor nutrient levels. Apply appropriate amounts of potassium fertiliser throughout the growing season.

Magnesium deficiency

Cause: Insufficient magnesium available to the tree.

Identification notes: Yellowing progresses inwards from the leaf margins and tips towards the main veins, leaving a band of dark green along the main veins. Most common in acid sandy soils.

Treatment and prevention: Get a leaf and soil analysis done to check soil pH and magnesium levels. Apply dolomite or magnesium oxide (choice depends on pH level). In future, do regular leaf and soil analyses to monitor soil pH and nutrient levels. Apply magnesium to the ground under the trees according to leaf and soil analysis results.

Manganese deficiency

Cause: Insufficient manganese available to the tree. Only a problem where too much liming material has been applied.

Identification notes: Affected leaves are slightly pale green, with most of the colour loss between the veins.

Treatment and prevention: Get a leaf analysis done to confirm the diagnosis. Treatment is generally not necessary as affected leaves normally grow out of the problem. In future, do regular leaf and soil analyses to monitor nutrient levels. Calculate liming rates carefully to avoid over-liming.

Yellow leaves

Zinc deficiency

Cause: Insufficient zinc available to the tree. Generally caused by high soil pH or high levels of soil phosphorus.

Identification notes: Affected leaves show uneven blotchy yellowing between the veins. With a mild deficiency, leaf size is only marginally reduced and leaf distortion is minimal. With a more severe deficiency, significant leaf distortion and reduction in size may accompany the yellowing.

Treatment and prevention: Get a leaf analysis done to confirm the diagnosis. Apply zinc to the ground under the tree. In severe cases, also spray chelated zinc onto the spring leaf flush. In future, do regular leaf and soil analyses to monitor nutrient levels. Apply zinc to the ground under the trees annually according to leaf and soil analysis results.

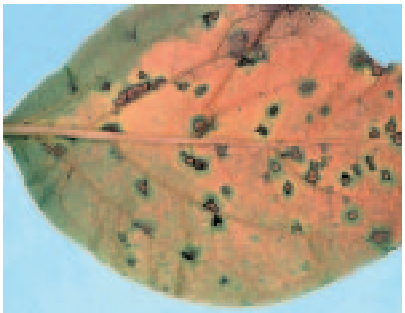
Red leaves

Premature defoliation

Cause: Inadequate applications of nitrogen fertiliser during the growing season or severe water stress after harvest or very low temperatures. Note that persimmon is a deciduous tree and leaves normally go from green to yellow to red in late autumn. In Queensland, premature defoliation is only a problem before fruit are harvested.

Identification notes: Causes an overall even reddening of leaves without the distinct spots of *Cercospora* leaf spot.

Treatment and prevention: There is no immediate treatment. In future, use leaf and soil analyses to ensure that fertiliser applications are adequate. Maintain adequate soil moisture levels after harvest to maintain healthy leaves.



Cercospora leaf spot disease

Cause: The fungus *Pseudocercospora* sp.

Identification notes: Severe leaf spotting may cause pronounced reddening of leaves and premature leaf fall. See also symptoms of *Cercospora* leaf spot on page 62.

Treatment and prevention: Once significant leaf spot symptoms are evident, it is generally too late to apply treatments. However, spraying with an appropriate chemical will help prevent build-up of the fungus. In future seasons, apply four protective sprays two weeks apart, starting when half of the flowers are open. Spraying the prunings and the leaf litter under the tree in winter helps to prevent carry over of the disease from one season to the next.

Brown margins on leaves

Severe magnesium deficiency

Salt burn may cause similar symptoms.

Cause: Insufficient magnesium available to the tree. Salt burn is caused by irrigation with salty water or over-use of fertilisers.

Identification notes: With magnesium deficiency, the marginal burn starts at the leaf tip and extends in towards the veins. With salt burn, damage is generally confined to the margins of the leaf. Magnesium deficiency is most common in acid sandy soils.

Treatment and prevention: For magnesium deficiency, follow the recommendations on page 61. For salt burn, do not apply fertiliser until the problem has been investigated. Get analyses done on soil, plant tissue and irrigation water. Also check the rates of fertiliser being applied and re-adjust if excessive. Water heavily to leach the salt out of the root zone. If water analysis confirms salty water, use another water source. In future, get a water analysis done before the start of each season, and follow the recommended fertiliser program to avoid over-fertilising.

Distorted leaves

Calcium deficiency

Cause: Insufficient calcium available to the tree. Generally caused by a combination of low available soil calcium and dry soil conditions. Availability of calcium from the soil is often restricted by an imbalance of potassium, calcium and magnesium.

Identification notes: Upper: a mild deficiency produces a slight distortion of the young leaves. Tips of affected leaves may also blacken. Lower: a severe deficiency produces significant distortion of older leaves and a major reduction in the size of younger leaves.

Treatment and prevention: Get leaf and soil analyses done to confirm the diagnosis. Apply lime, dolomite or gypsum according to the analysis results. A foliar spray of calcium provides a short-term response. Spray to thoroughly wet the young leaves. In future, do regular leaf and soil analyses to monitor nutrient levels. Apply appropriate amounts of liming materials as required. Ensure adequate water is applied during the leaf development period.

Distorted leaves

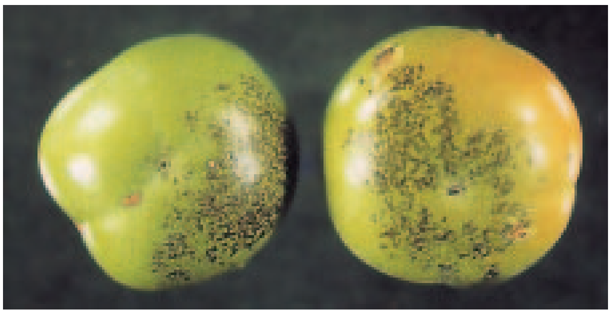
Boron deficiency

Cause: Insufficient boron available to the tree.

Identification notes: Upper: field symptom showing the distortion of young leaves. Lower: close-up of affected leaf showing the rolling and twisting of the leaf blade. Brown corky tissue is sometimes present. Boron deficiency is difficult to distinguish from calcium deficiency.

Treatment and prevention: Get leaf and soil analyses done to confirm the diagnosis. Apply borax or Solubor to the ground under the trees at rates according to the analysis results. These must be applied very evenly otherwise toxicity may result. The best method is to mix the required amount in water and spray it on the ground under the trees. In future, do regular leaf and soil analyses to monitor nutrient levels. Apply appropriate amounts of boron as required. Ensure adequate water is applied during the leaf development period.

Spots or marks on fruit



Manganese toxicity (green blotch disorder)

Cause: High uptake of manganese from the soil. Occurs in soils with high manganese levels when pH falls below 6.5 (1:5 water test).

Identification notes: Affected fruit have uneven colouring with small black spots in the green blotchy areas.

Treatment and prevention: Get a leaf analysis done to confirm the diagnosis. Apply lime or dolomite to raise soil pH to 6.5 (1:5 water test). In future, do regular leaf and soil analysis to monitor nutrient levels. In high manganese soils, maintain soil pH at 6.5 or above (1:5 water test).

This book will allow growers to monitor and schedule fertiliser practices more efficiently. It will also improve their understanding of the effects of nutrients on fruit quality and yield.