Mango information kit

Reprint – information current in 1999

REPRINT INFORMATION – PLEASE READ!

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

This publication has been reprinted as a digital book without any changes to the content published in 1999. We advise readers to take particular note of the areas most likely to be out-of-date and so requiring further research:

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- Financial information—costs and returns listed in this publication are out of date.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

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

This publication was last revised in 1999. The information is not current and the accuracy of the information cannot be guaranteed by the State of Queensland.

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

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

Queensland Government

Growing THE CROP

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

Some important mango terms

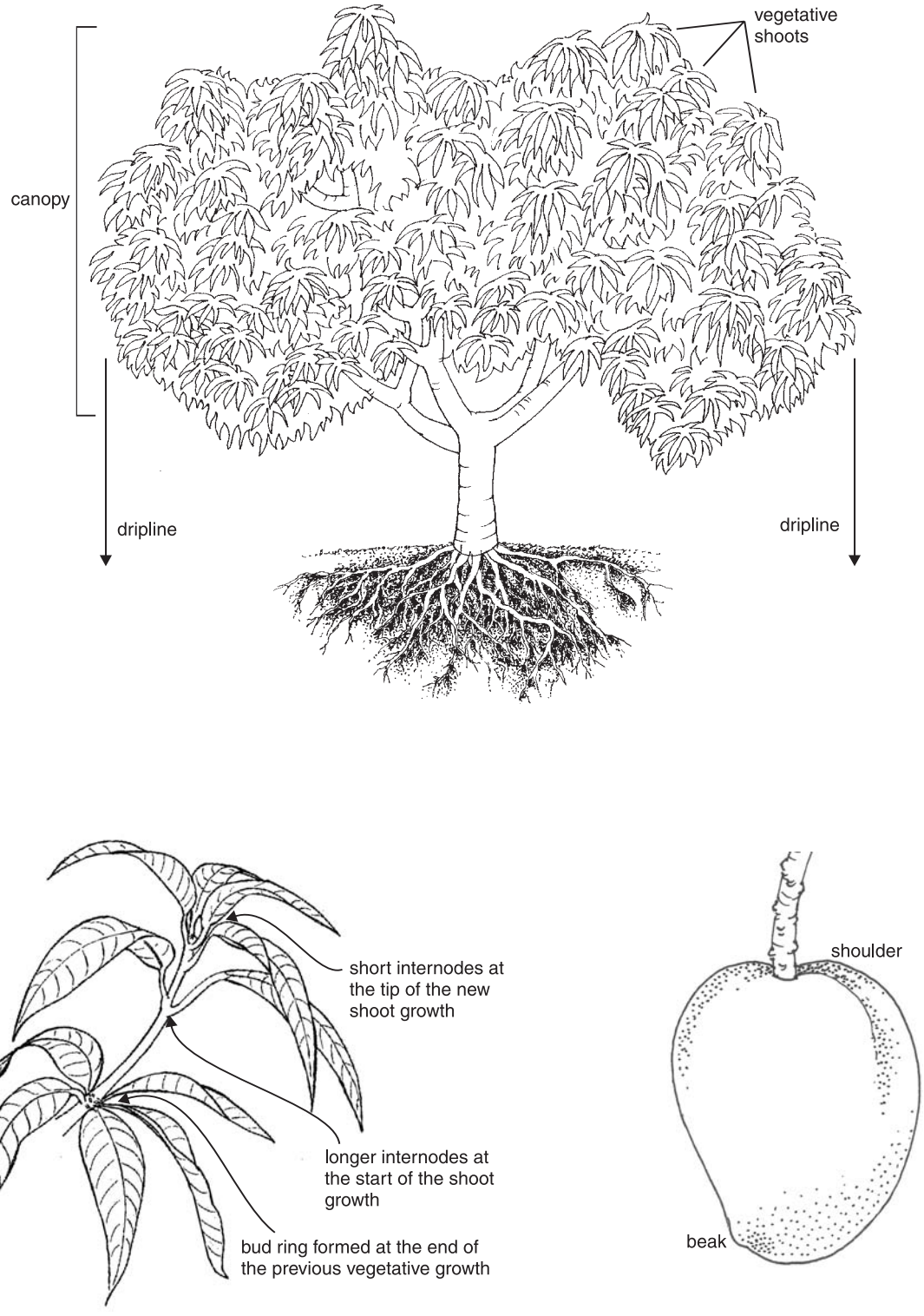


Figure 1. *Parts of the mango tree and fruit*

Getting the crop started

A mango orchard can last a long time, so it is important to plan the orchard and prepare the land carefully. Setting up an orchard that will be profitable in the long-term requires careful planning and attention to detail. Mistakes made at this stage are difficult and costly to correct. The following steps tell you what to do to give your orchard the best possible start.

Plan the orchard layout

Planning the orchard layout is a complex procedure and you may need to get some expert assistance. Conservation extension officers with the Queensland Department of Natural Resources provide advice and can help you prepare a farm plan.

The preparation of a farm plan using a photographic base map can be useful. Farm features such as topography and soil type can be shown on overlays that are easy to change until the best farm layout is obtained.

Your aim is to enable easy, all-weather access to the orchard, minimise soil erosion yet provide good surface drainage of water, and achieve a planting arrangement which makes trees easy to manage and gets the best possible production from a given area of land.

A well-planned orchard layout should include:

- safe all-weather access roads
- row direction to suit light interception (in most situations north/south is the preferred orientation), runoff control, drainage and machinery operation
- conveniently positioned buildings and sheds
- windbreaks
- specialised erosion control and drainage structures
- irrigation design, including dam sites.

Here are some important points for planning and designing your farm layout.

On-farm access

Safe all-weather access on the farm is essential. There are two key areas.

Heavy vehicle access from the road to the shed. These roads should be capable of carrying trucks transporting fertilisers, chemicals, cartons and fruit to and from the farm in all weather conditions.

Orchard access roads. These roads are best located in dry areas such as ridge lines or on contours. They are used for moving machinery and spray equipment between sheds and the orchard and for trailers carrying fruit. These roads should have well-formed crowns and adequate side drains to allow access in all weather. Any roads that are used for transporting fruit should be smooth to minimise bumping and damage to the fruit while transporting it to the packing shed.

Control erosion

Even if your orchard is situated in a relatively flat area, it is still important to consider erosion and runoff control. Uncontrolled water runoff erodes valuable topsoil and exposes the surface roots to desiccation. It may also pool within the orchard, causing waterlogging.

Diversion banks. These are built to prevent runoff water flowing in from outside the orchard. They are usually built directly above the orchard to divert excess runoff into a stable watercourse or grassed waterway. Diversion banks should be established before the orchard is developed.

Contour drains and v-drains. Build contour drains and v-drains to direct runoff safely through the orchard and into stable waterways. Do not plant orchard trees where runoff naturally concentrates in gullies or depressions.

Water courses and dams. Gullies, creeks and depressions should be disturbed as little as possible. Leave trees along gullies and creek banks to keep them stable. Seek professional advice on siting and constructing dams. Water extension advice may be available from some offices of the Department of Natural Resources.

Row direction and length

Although it is preferable to run rows in a north/south direction, row direction and length should suit the design needs of the orchard plan. Try to have long rows with intersecting roadways every 200 m for efficient use of machinery.

On slopes of up to 4%, rows can be run across the slope or up and down the slope without any structures to control soil erosion within the orchard.

On slopes of 4 to 15%, rows can be run across the slope or up and down the slope provided surface drains are built within the orchard to control runoff water. If rows are run across the slope, locate the rows and drains as close to the contour as possible and with a fall of 2 to 5% to safely remove water. If rows are run up and down the slope, build contour drains at least every 150 m down the slope. A 15% slope is the safe maximum limit for working a two-wheel-drive tractor across the slope.

Try to avoid slopes greater than 15%. If trees are planted on these slopes, run rows up and down the slope for safe use of machinery. Contour drains are required at least every 150 m down the slope.

Mounding

Where there is a limited depth of good topsoil, low profile mounds may be built to improve soil depth and if they are constructed correctly, they can be used to drain off excess water. These mounds are suitable for slopes of up to 15%. They are best run on the contour across the slope where the slope is even, or up and down the slope where the slope is uneven or broken.

Irrigation

Plan the irrigation system to make sure that you can supply enough water to the trees during critical times for fruit production. Mature trees require 1500 litres of water each week during hot weather in November and December. You should allow for a total water usage of 6 ML per hectare in hot dry areas in north Queensland. Orchards in central and southern Queensland will use less. Check your water quality at the same time. A conductivity of over 2 deciSeimens per metre will be detrimental to tree growth.

Windbreaks

Windbreaks are important for mango orchards as wind damages fruit and reduces its quality. Even minor wind damage predisposes leaves and fruit to infection by bacterial black spot. Use existing stands of timber where possible; otherwise plant windbreaks well before the orchard is established.

Seek expert advice on windbreak design and development from land vegetation management officers of the Queensland Department of Natural Resources. An example of how these factors are integrated into an orchard design plan is shown in Figure 2.

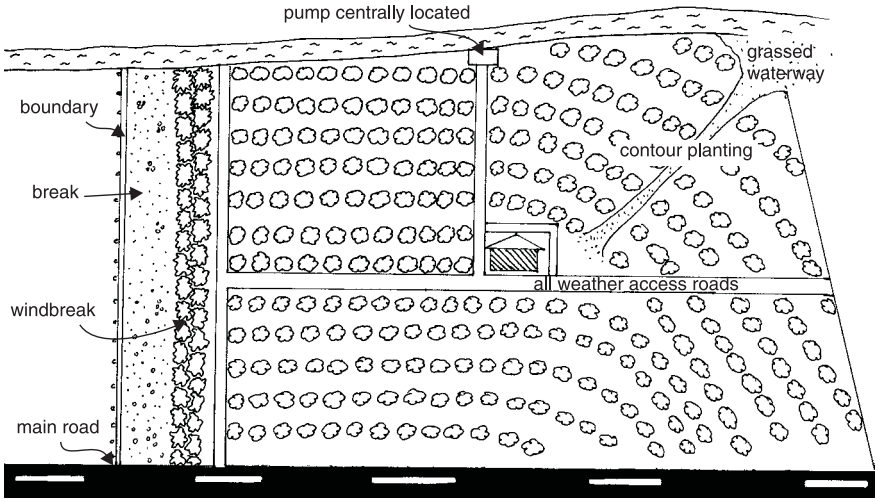


Figure 2. *An example of an orchard design plan.*

Choose varieties

a key issue
Mango varieties
Section 4 page 22

Although some varieties are more sensitive to cold than others, every variety can be grown in each of the mango growing regions. More importantly, despite the large number of mango varieties available, only a few are well established in the domestic market. Australians prefer the flavour of Kensington Pride, but other varieties such as R2E2 and Keitt are well accepted by Australian consumers. R2E2 in particular, is rapidly gaining favour on the domestic market and extensive areas of this variety are being planted. Mango processors prefer Kensington Pride and may not accept other types. This limits the market options you have for some varieties. There are two main factors to consider when making your decision.

HINT
To contact the main markets and market agents refer to Section 6 for contact details.

The market you wish to target with your crop. Each market has preferences for certain varieties or sizes of fruit. You may choose to send most of your crop to Hong Kong for instance. This market likes large, highly coloured fruit such as R2E2. Talk to the agents, resellers and retailers at each of the markets to find out what type of fruit they prefer. If you wish to grow for a niche market you can consider other varieties, for example the Thai lines favoured for green eating.

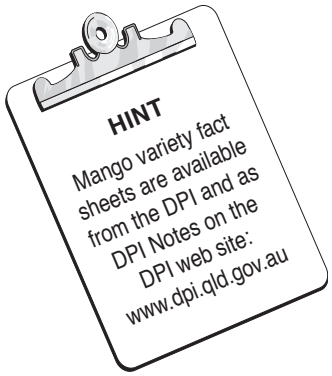
The maturity time. The maturity of mangoes, even within a variety, varies with longitude and latitude. As a general rule, the closer orchards are to the coast and the further north, the earlier the fruit matures. Check the maturity time in your region and see how it will compare with the intake and average prices at the market at that time. This information will let you compare varieties on the basis of the returns you can expect for your harvest time and market. Prices tend to be higher both early and late in the mango season. In a large orchard you can consider planting more than one variety to spread harvesting over a longer period.

a key issue
Maturity times
Section 4 page 39

New varieties are now becoming more widely available. They are worth including in your consideration. They include Celebration from the Northern Territory and Kensington Red, Honey Gold, Pearl and B74 (yet to be named) in Queensland. These varieties are under Plant Breeder's Rights and have restrictions on propagation or marketing arrangements, that must be considered by the intending grower. Mango breeding programs in tropical Australia and subtropical Queensland are currently developing varieties suited to Australian conditions that combine the flavour of Kensington Pride with better shelf life, disease resistance and more reliable cropping.

As the rootstocks and scions of most of the mango varieties grown are compatible, the variety of existing trees can be changed by topworking those trees to a new variety if this is required.

Tree spacing



The tree spacing you choose should optimise the potential yield per hectare while allowing for good machinery access for management operations such as spraying and harvesting.

In old orchards mango trees were planted at relatively wide spacings such as 12 m x 12 m (70 trees per hectare) or 10 m x 10 m (100 trees per hectare). This allowed the mango tree to grow to its full size. Changes in management and different varieties mean that trees are now kept smaller and can be planted much closer together. Although smaller trees do not yield as much fruit per tree as a larger tree and must be pruned regularly, this is offset by the larger number of trees that can be planted per hectare and the easier and cheaper management and harvesting of smaller trees.

Make sure the row spacings are wide enough to allow for machinery access and for sunlight to penetrate the trees from the top to the bottom of the exposed side. Tree spacing will vary according to the variety. In general trees within the row should have their canopies just touching or be separated by a small gap between the trees to allow for air movement around the canopy when they reach their maximum size. Once trees have reached their maximum desired size you will need to prune every year to keep the trees at this size.

Topworking
Section 4 page 46

Common spacings

A typical medium density Kensington Pride mango orchard is planted at 9 m between rows and 6 m between trees, making 185 trees per hectare. Other varieties are less vigorous so you can choose to plant them much closer together. Table 1 gives the range of plant spacings suitable for each of the major mango varieties and Figure 3 shows two possible tree spacing arrangements for R2E2. Choose the wider spacing in wetter areas or if you do not want to prune your trees to the extent needed to maintain the higher densities.

Canopy management
This section page 27

Table 1. *Suitable plant spacings for some mango varieties*

Variety	Row spacing (m)	Tree spacing (m)	Trees per hectare
Kensington Pride	9 - 10	6 - 9	111 - 185
R2E2	7 - 9	4 - 6	185 - 357
Keitt	6 - 8	3 - 6	208 - 555
Palmer	7 - 9	4 - 6	185 - 357
Kent	7 - 10	4 - 8	125 - 357
Nam Doc Mai	9	4 - 6	185 - 278

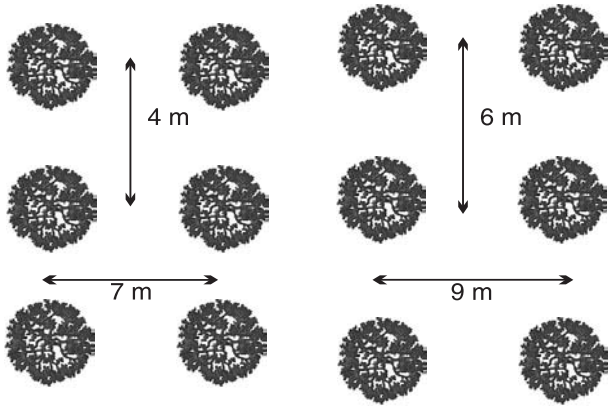
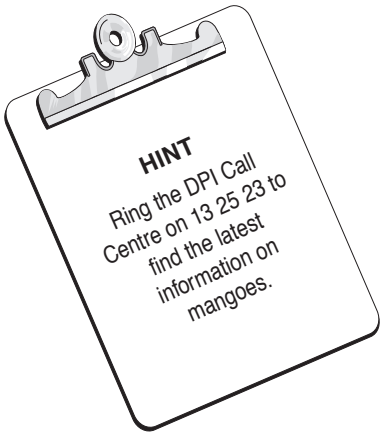


Figure 3. *Two possible tree spacing arrangements for R2E2*



Hedgerows

An alternative option for orchard design is hedgerowing. Hedgerowing is relatively new in mango culture in Australia. Trees are planted close together in the row and mechanically pruned to produce a slightly vase-shaped hedge, with fruit hanging free of the foliage.

As tree growth is strictly controlled, interrow spacings need only be wide enough to allow a year's growth as well as vehicle access and penetration of sunlight. In most instances trees are trained to a maximum height and diameter spread of 4 m. Minimum spacings within the row should be 3 m for R2E2 and 4.5 m for Kensington Pride.

Before deciding to grow trees as a hedgerow, investigate the latest results and talk to a grower who has been using the system.

Order trees

Once you have chosen the varieties and worked out the row and tree spacing, calculate the total number of trees you will need. You can grow your own trees or buy the trees from a nursery.

Nurseries
Section 6 page 5

Order the trees 12 months before you intend planting to make sure they are ready when you need them.

If you plan to grow your own trees you also need to plan well in advance. Nursery production is a specialist job and takes time and effort, particularly if you are going to produce grafted trees. There is detailed information on how to propagate and graft your own trees elsewhere in this kit.

Propagation
Section 4 page 9

Clear the land, leaving appropriate windbreaks

Start any clearing at least 12 months before planting. First identify and mark strategically placed existing stands of timber to act as perimeter windbreaks. Before clearing, get professional advice from land vegetation management officers of the Queensland Department of Natural Resources. Also check your local authority for any tree clearing ordinances that may exist. Then clear and stickrake the land to remove roots larger than 5 cm in diameter. Allow smaller roots time to break down before planting. Stack the timber into windrows for burning; don't push it into gullies and depressions. Leave gaps in the windrows every 30 m to allow safe removal of runoff water.

Mark out the rows

On slopes, rows across the slope are marked parallel to a surveyed key line. Wire is tightly stretched between two people at right angles to the key line and points marked every 20 m along the row (Figure 4). Rows up and down the slope are usually marked at right angles to the contour or parallel to the longest row.

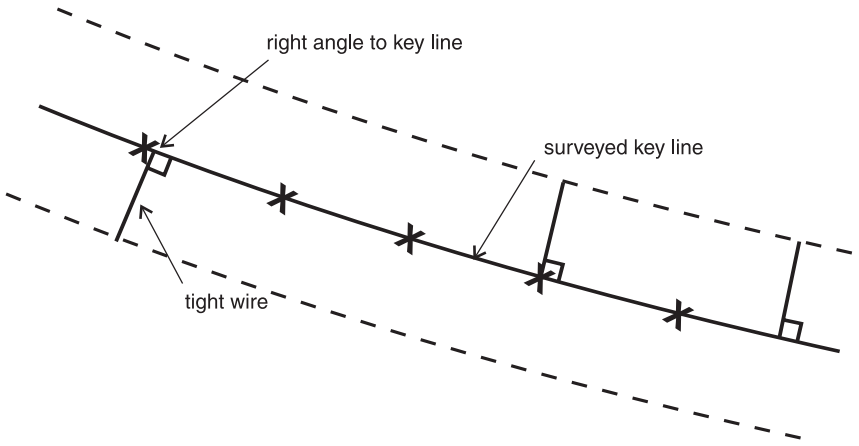


Figure 4. *Marking out parallel rows across a slope*

Deep rip along the rows

On land that has been previously cultivated or grazed, deep rip to a depth of at least 60 cm along the rows. This is important to improve soil aeration and to break up any compaction layers that have developed in the soil. Ripping will also assist with the drainage of wet areas. If ripping downhill, lift the toolbar every 30 to 40 m to avoid subsequent scouring by water down the rip lines.

Build drains to control runoff

Main diversion drain above orchard

On sloping land, construct a major contour diversion drain above the orchard to divert water into a stable waterway or dam. The drain should be at a gradient of 1 to 5% and large enough to handle the water from the catchment above. Keep the steeper sections of the drain furthest from the waterway or dam unless you have very stable clay soils. Establish a creeping grass such as carpet grass, couch or African star grass in the drain channel to prevent scouring.

Contour drains and/or v-drains within the orchard

Within the orchard, there are two options to control water flow and provide drainage. The first is to build major contour drains at least every 50 m or so down the slope. These are built to similar specifications to the main diversion drain above the orchard.

The other option is to build shallow wide v-drains in the centre of the interrow area. V-drains have a maximum excavation of 20 cm and are usually built by a grader or tractor-mounted blade.

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

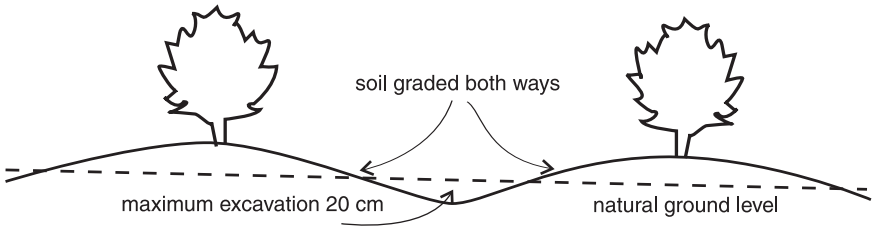


Figure 5. *Across slope rows (cross-section view)*

For rows up and down the slope, v-drains are constructed in every interrow area to control side slope runoff and to prevent water scouring down the tree rows (Figure 6). Soil from the drain is moved both ways on to the proposed tree lines.

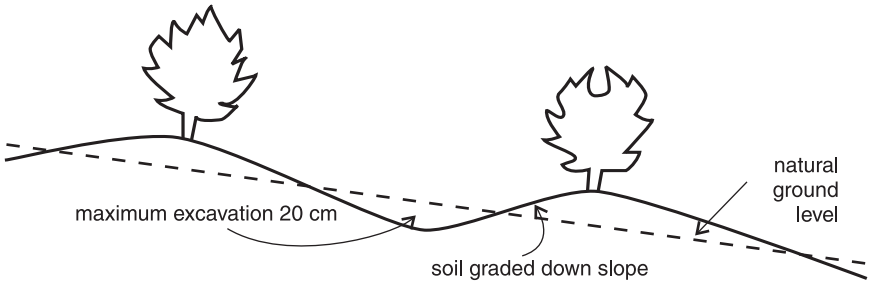


Figure 6. *Down slope rows (cross-section view)*

Immediately after building v-drains, grass all disturbed areas to minimise erosion. Carpet grass and couch are commonly used but consider a taller growing grass such as Rhodes grass as this can later be a valuable source of mulch for under the trees.

Plant windbreak trees

Where it is necessary to plant windbreak trees to supplement natural timber, plant at least 10 m from the closest orchard rows to allow machinery access and to minimise competition for water and nutrients. Seek advice from land vegetation management officers from the Queensland Department of Natural Resources.

When planting windbreak trees, first deep rip rows to a depth of at least 60 cm before planting. If ripping downhill, lift the toolbar every 30 m to prevent scouring by water down the rip lines. Plant the trees 4 m apart. Mulch well with coarse straw. Install a separate irrigation line to keep the trees well watered. Regular applications of small quantities of a mixed tree fertiliser will promote rapid growth. Maintain a weed-free area around the trees.

Do a soil analysis and apply required pre-plant fertilisers

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

Samples should be analysed at least six months before planting. Discuss the results with your local farm supply agent and work out what pre-plant fertilisers are required. Fertilisers such as phosphorus, gypsum, lime, dolomite and some trace elements, are applied before planting. Apply nitrogen and potassium fertilisers to the trees after planting when they show signs of growth.

Cultivate strips along the tree rows

Cultivate one-metre wide strips along the tree rows. Cultivation along the tree rows aids tree establishment and reduces initial weed competition, as well as incorporating any fertiliser applied. It is very important that fertilisers of low solubility are well incorporated before planting. Tyned implements or a Turbo-rota are preferred for cultivation. Don't overuse a rotary hoe as it can lead to soil compaction and soil structural problems as well as causing later settling of the tree row below ground level. This settling may cause subsequent soil erosion from water movement along the row.

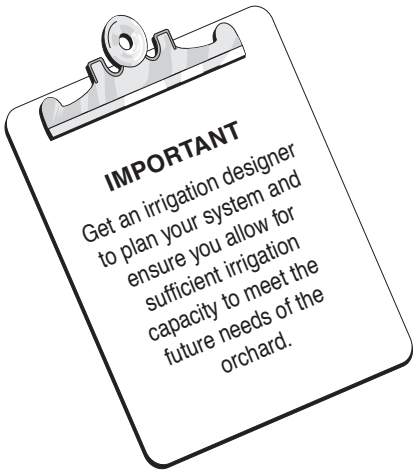
Grow a green manure crop and grass the interrow

The interrow area is usually planted to a grass to minimise erosion. A low spreading grass such as carpet grass or couch is most commonly used but a taller growing grass such as Rhodes grass can provide a source of mulch for under the trees.

If possible grow a green manure crop in the cultivated strips. Use a hybrid forage sorghum that will give a large bulk of green material. A side dressing of urea or nitram after crop emergence will help to promote good growth. Fertile soils will not need extra nitrogen. Slash before the green manure crop seeds and disc into the soil.

Mark out the tree plant sites

Mark out the tree sites with a peg. Don't spread mulch at this stage. If you are going to mulch the young trees do it after planting.



Install the irrigation system

Install an irrigation system on the basis of a design plan prepared by a qualified irrigation designer. Most mango orchards use minisprinklers rather than trickle systems or large diameter throw sprinklers. Low profile sprinklers are best to avoid wetting the canopy. Minisprinklers with a microspray feature are useful when starting the orchard. The microspray feature is used for the first two years to limit water throw. Use sprinklers with an output of 80 to 250 L per hour. Remember in the design of the irrigation system to allow capacity for the extra sprinklers to water your windbreak trees. Do not bury irrigation lines as tree roots can block pipes through strangulation.

Plant the trees

Before you plant the trees make sure they are healthy, disease-free and have been hardened to full sunlight. Condition trees by spacing them wider apart in the nursery and gradually removing shading. If the trees are not hardened they can easily be sunburnt. Cut off any side branches to leave a straight stem.

Diseases such as bacterial black spot and mango scab can be introduced into an orchard through diseased nursery stock. Don't plant trees that are stunted, root bound or very yellow.

When to plant

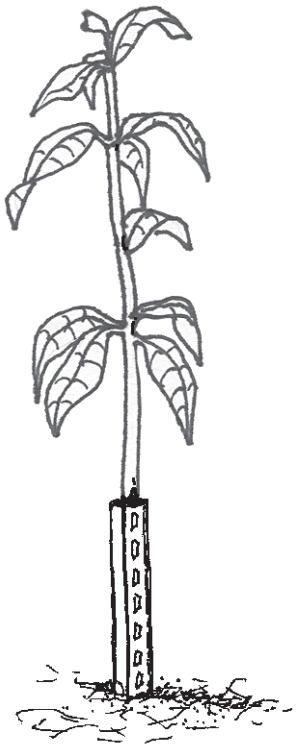
March to May and September are the best times for planting mango trees as the mild weather is ideal for tree establishment. If there is danger of frosts, plant in September after the frost danger is over.

Planting procedure

One or two days before planting, water thoroughly to wet tree sites to a depth of 30 cm. Follow these planting steps.

1. Dig a hole slightly deeper and wider than the plant container. If you are using a posthole digger or auger, roughen the sides of the hole with a crowbar before planting. Do not place fertilisers or organic materials into the hole.

2. Remove the tree from the container. Examine the root ball, straighten any large roots and prune off badly twisted ones. Trees with damaged roots can die. Gently tease out some of the roots at the bottom of the root ball and remove a little of the potting mix around the edge of the root ball to expose some of the roots.
3. Place the tree in the hole. Half-fill the hole with soil, pressing it into contact with the root ball using your hands. Fill the hole with water and let it drain before completing filling.
4. Firm the soil down gently with your hands, and leave a slight basin around the tree to hold water (Figure 7). Water again.
5. Mulch the tree with coarse mulch, such as sorghum stubble, 10 to 15 cm deep.
6. Where light frosts are possible, wrap the trunk in sisalation or similar insulating material and put plastic or hessian over the top of the tree during winter nights and early mornings. It is usually not necessary to stake young mango trees (Figure 8).
7. Water the tree regularly until it is well established and the roots are growing into the surrounding soil. Depending on weather conditions, you may need to water at least twice a week for the next four weeks.



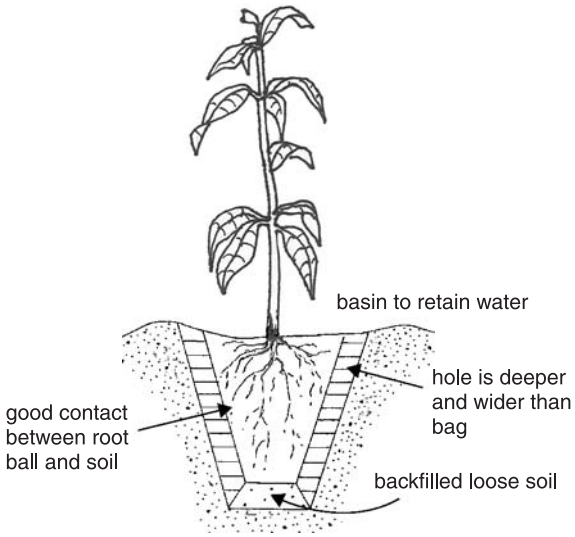


Figure 7. *A correctly planted tree*

Figure 8. *When tree guards are not used, wrap the trunk in either a polythene tree protector sleeve or one thickness of sisalation to protect it against light frosts and animal and herbicide damage*

Managing young trees

The main focus of management at this time is to build a strong healthy tree that can carry plenty of fruit when it starts to bear. Fruit production should not be permitted until after the second or third year of growth, depending on the development of the tree. Correct fertilising, watering, pruning and pest and weed management all help to produce a healthy and productive tree.

Fertilising

Nutrition
Section 4 page 35

After planting do not apply any extra fertiliser until the trees have shown signs of growth and the first flush has started to harden. The preplant application based on the initial soil test should have corrected any existing nutrient deficiencies. Then apply small but regular quantities of fertiliser to the young trees (Table 2). Excessive quantities can lead to root burn or over-vigorous shoot growth. These branches may break off from the main trunk as they mature.

Table 2. *Fertiliser program for young mango trees*

Years from planting	Timing	Amount of fertiliser per tree (N:P:K – 15:4:11)
1	Every 6 - 8 weeks	30 - 60 g
2	Every 6 - 8 weeks	80 - 120 g
3	December or after crop removal March	500g plus 500 g gypsum 250g
4	December or after crop removal March	750 g plus 1000 g gypsum 400 g

Apply fertiliser in a broad ring around the young trees as shown in Figure 9. Do not apply closer than 20 cm to the tree trunk.

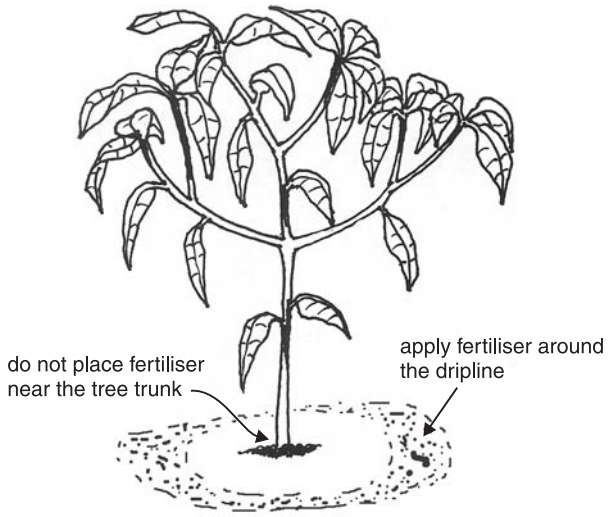


Figure 9. *Fertiliser application for young trees*

Watering

a key issue
Irrigation management
Section 4 page 25

Although the mango tree is considered to be drought-hardy, a good water supply is still important to ensure good growth and high quality fruit. Too much water can lead to waterlogging and root rot and too little can stress the tree and stunt growth.

Young trees need to be watered regularly. Table 3 is a guide to the amount of water a young tree may need each week. The figures are only a guide as soils vary widely and rainfall is ignored. Sandy soils hold less water than heavier loams and clay loams, so you will need to apply less water each time, but water more frequently, to ensure that the trees have an even supply of water. Be sure to water the whole root zone. If you are not sure how deeply you are watering, dig down with a soil auger and check. The soil should be moist for at least 30 cm after planting. Increase watering depth as the roots grow down. Mulching around the trees with coarse straw will help conserve water and reduce the frequency of irrigation. However, remember that even if the trees are mulched it is still important not to allow the roots to dry out as many of the feeder roots will be closer to the surface.

Table 3. *A guide to the water needs of a young mango tree*

Years from planting	Amount of water (litres per week)	
	May to August	September to April
1	20	50
2	100	250
3	200	350

Low profile minisprinklers are best suited for mango irrigation because water can be kept off the foliage (Figure 10). During the first two years place one minisprinkler beside each tree and set it in the microspray mode to limit the spread of water. Towards the end of the second year, change it to minisprinkler mode to increase the diameter of the wet area and encourage the roots to spread.

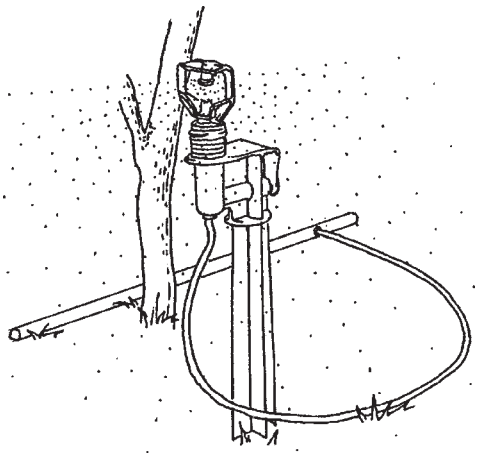
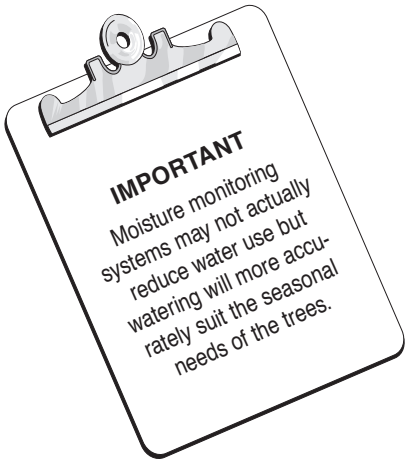


Figure 10. *Minisprinkler watering system for young trees*

Monitoring soil moisture

Once the trees are established, water management can be greatly improved by basing watering rates and frequency on a soil moisture monitoring system. There are five main options, each with its advantages and disadvantages. The choice will depend on the degree of accuracy required and the available budget. The choices are:

- tensiometers
- soil moisture sensors
- neutron probes
- capacitance probes such as Gopher, Diviner or Enviroscan
- evaporation pan readings.



Place the sensors for your monitoring system in a position under the dripline of the tree where most of the feeder roots will be. The position should receive an even water application and the soil type should be representative of the block.

Tensiometers

Position two tensiometers, one 30 cm long and the other 60 to 90 cm long, in each irrigated block to the depths shown in Figure 11. Place on the north-eastern side of a healthy tree, inside the dripline and where they will receive water from sprinklers. Read tensiometers before 8 a.m. Start watering when the shallow tensiometer reads 20 cb (on sandy soils) and 30 to 40 cb (on loam and clay loam soils). Stop watering when the reading on the deep tensiometer falls to 10 cb. Reposition tensiometers every second year in winter to the new dripline position.

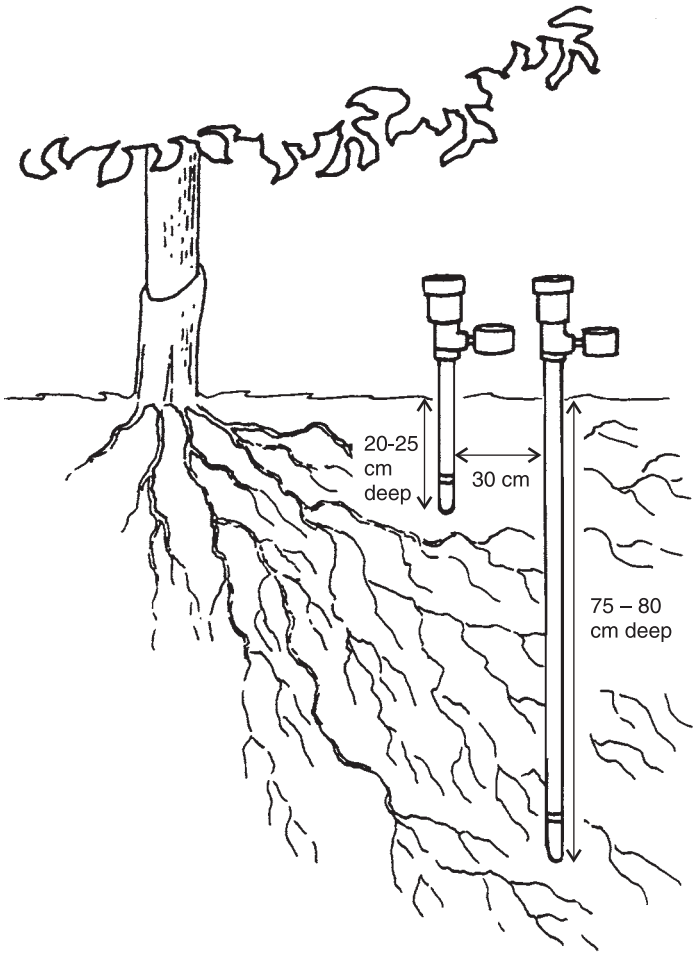


Figure 11. *Tensiometers in place, (a) in the major root zone and (b) below most roots*

Other monitoring systems

Moisture monitoring systems
Section 4 page 28

In most cases the system will be set up by an irrigation consultant who will advise you how to interpret the readings. With the neutron probe, advice on watering will be provided by the consultant who takes the neutron probe readings. The Enviroscan probe comes with a software program that helps you to schedule your irrigation.

Scheduling watering using evaporation pan readings is based on the fact that tree water use is related to evaporation. To use this system effectively you will need to understand the water holding capacity of your soil and be prepared to regularly spend time to calculate water use from weather data. This system does not easily account for watering efficiency factors such as the need to account for runoff from intense rainfall.

Training and pruning

Young mango trees are pruned to ensure that the tree develops a strong framework with plenty of branches. As the mango tree is a terminal bearer (it flowers from the ends of the branches), the more branches

the tree has the better the potential yield. The aim of tree training is to develop a mature tree that is 4 to 4.5 m tall with a spreading inverted umbrella shape, or a square appearance if trees are managed as a hedgerow or mechanically pruned.

Start training young trees as soon as they are established, normally six to eight weeks after planting. Trees planted in late autumn or winter should not be pruned until spring growth starts.

Then follow these steps:

1. Cut the young tree to a single trunk about 80 to 90 cm above the ground (Figure 12). Keitt trees should be cut to encourage the first branches at 100 to 120 cm. Make a cut just below a node to encourage the development of numerous side shoots.
2. Select three side shoots to become the main branches. These selected side shoots should come from slightly different heights on the trunk to avoid the risk of a weak union developing later. Prune the side shoots after they have produced two to three flushes, again cutting below the node area (Figure 13). Shorten the selected side shoots to a length where they have grown about 1 to 1½ flushes or about 60 to 80 cm, once again cutting below the node area. The side shoots selected, as well as being well-spaced around the tree and emerging at different levels, should also arise at about a 30 to 45° angle to the main stem. This has a two-fold effect of helping to keep the centre of the tree open and delaying the time taken for the lower branches to reach too close to the ground (Figure 13).
3. New shoots will grow from the pruned side shoots. Select two or three of these shoots and repeat the pruning procedure of step 2. Remove all other shoots (Figure 14).
4. Continue pruning in this way until you obtain the desired framework or until flowering. Figure 15 shows the plan view of the framework.

In all systems, keep the insides of the tree clean of sucker growth and do not allow shoots to develop below the graft union.

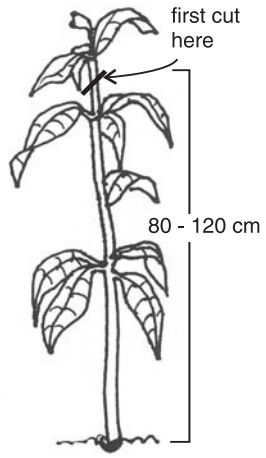


Figure 12. *First cuts*

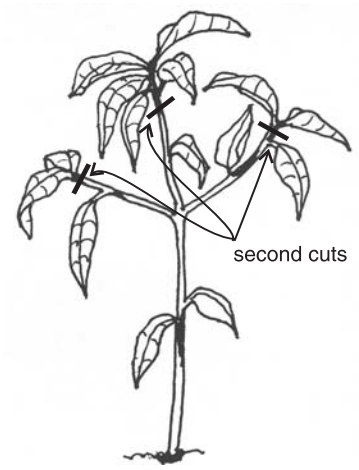


Figure 13. *Second cuts*

Figure 14. *Continue pruning new shoots*

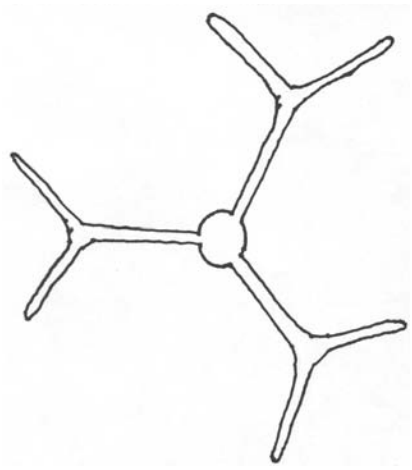


Figure 15. *Plan view of tree framework*

Control flowering

Do not allow fruit production until after the second or third year of growth, depending on the development of the tree. If flowers do emerge, let them fully develop and set small fruit before cutting them off at the base. If they are cut off too early, the tree may re-flower. Removal of flowers promotes further vegetative growth.

Control weeds and apply mulch

Weed control around young trees is particularly important because they find it difficult to compete with weeds for water and nutrients. Weeds are controlled by mulching or applying a herbicide under the trees.

Coarse hay or straw such as sorghum stubble is good mulch. The interrow area can be a valuable source of mulch, especially when planted to a tall-growing grass that can be slashed several times. Mulch in late winter to about 10 to 15 cm deep and extending just beyond the

dripline of the canopy. To avoid collar rots do not let mulch contact the trunk. Mulching is mainly used for young trees. A few growers do mulch mature trees but most growers rely solely on herbicides to maintain a weed-free area under the canopy.

If you are using herbicides do not allow the herbicide to contact any green part of the tree, including the trunk. Use a shielded, low-pressure fan or flood nozzle or a rope wick applicator. Herbicides are usually applied in a strip along the tree row extending to just outside the dripline. Table 4 lists herbicides that are registered to control weeds in mango orchards.

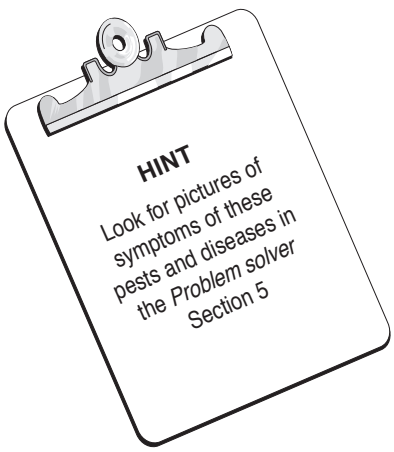
If you are cultivating to control weeds, do not cultivate within 1 m of the tree.

Table 4. *Herbicides registered for use in mango orchards*

Chemical	Products	Weeds controlled
paraquat + diquat	Sprayseed 250	Knockdown effect on broadleaf weeds and annual grasses.
glufosinate-ammonium	Basta	Broadleaf weeds and grasses.
fluazifop-p	Fusilade	Post-emergent control of grasses.
haloxyfop	Typhoon 130, Verdict Appeal	Systemic action. Use on actively growing grasses.
pendimethalin	Stomp 330 E	Residual herbicide for grasses and broadleaf weeds.
glyphosate	Glyphosate 360, Glyphosate 450L, Glycel 360, Glyfox, Harpoon 360, Weedmaster 360, Roundup ®, Ranger 360 ®, Ricochet 360® , Sanos 360 ®, Squadron, Touchdown ®, Glyphoz ®, Pacer®	Systemic action. Use on actively growing broadleaf weeds and grasses.

Control pests and diseases

Young mango trees are susceptible to a range of pests and diseases but none require routine treatment. Inspect the trees regularly for signs of pests and diseases and apply control measures only when necessary.



Pests

The main problems to look for are mango tipborer, mango shoot caterpillar, leafminer, fruitspotting bug and mango scale. Mango tipborer can kill young shoots and should be controlled to encourage maximum growth in young trees. If the young growing tips are affected, diagnose the cause of the problem and then spray with an appropriate chemical from the *Problem solver handy guide*.

Diseases

Look for anthracnose, bacterial black spot and mango scab on young leaves during growth flushes. Wet, humid conditions are the most favourable for disease development. You should spray new growth with a protectant fungicide if these diseases are a problem in your trees. Bacterial black spot and mango scab in particular, will require regular spraying to keep under control. Prune out dead branches to keep the trees clean and minimise disease pressure.

Prevent frost damage

Young trees can be killed by frosts. The protective insulation materials recommended at planting will give adequate protection in mild frosts. You can also take extra precautions:

- In small orchards, wrap a thick bundle of dry straw around the trunk and fasten with twine. The straw should extend from the ground up past the main branching area into the foliage. Some foliage damage is acceptable as long as the main trunk and scaffold branching area is not damaged.
- A copper spray just before winter will limit damage by reducing the number of nucleation bacteria around which the ice crystals form.
- The bare herbicide strip along the young tree line, provided it is moist and firm, gives added protection against frost.
- The grassed interrow area increases the frost hazard in newly planted orchards if the grass is left to grow long and then dry off during winter. Mow the grass to keep it short.
- Dry mulches can also increase the severity of frost damage. Keep the mulch wet but do not over water the root zone in winter.
- Turn the irrigation on before the frost settles.

Frost-damaged trees lose leaves, branches and roots and will need less fertiliser and irrigation than undamaged trees of the same age. Frost damage may not show up until several months after the damage was inflicted. It will show on the trunk as a corky rotting area. Don't start removing frost-damaged wood until about October when the full extent of damage should be visible.

Managing bearing trees

Mango trees come into commercial production in the third or fourth year after planting. Once the trees begin to bear the focus of management changes. Before bearing, the aim is to develop a strong healthy framework with the maximum fruit-bearing surface. When trees are bearing the aim is to produce the maximum production of quality fruit. The market demands only top quality, highly coloured mango fruit. This type of fruit can be achieved by applying sound management practices and following key steps.

Fertilising

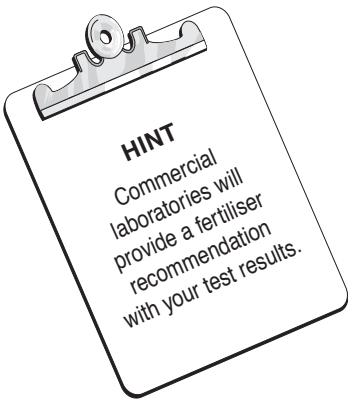
Once trees are bearing, the timing of fertiliser applications is as important as the quantity applied. Vegetative growth should not be encouraged at the expense of flower and fruit production. Too much fertiliser at the wrong time can also affect fruit quality.

Nutrition
Section 4 page 35

Of the nutrients, timing the nitrogen and potassium applications is the most critical. Most of the nitrogen and potassium needs are applied as soon as harvesting is completed and at the end of the wet season, with a small supplementary amount before flowering. Extra potassium can also be applied during active fruit development. Phosphorus can be applied at any time. Calcium, magnesium and boron are best applied after harvest during the vegetative growth stage and/or immediately before floral bud break. Micro-nutrients such as iron and zinc are best applied as a foliar spray on young developing foliage.

The rate of fertiliser you apply should be guided by leaf and soil analysis results. If leaf nutrient levels fall within the optimum range, the fertiliser program from the previous season can be repeated with a small allowance for tree growth. If leaf nutrient levels fall outside the optimum range, adjust your program for that nutrient, targeting the optimum range.

Leaf and soil analysis



The best time to do soil and leaf analysis is in May or June before the flower buds break. Do an analysis for each of the varieties and blocks in your orchard that are treated differently. Buy the analysis kits from your local farm supply store and follow the instructions to send the sample away for analysis. In most cases the results will be back in two weeks.

Take leaves from the most recently matured shoots. It is best to take the third or fourth leaf down from the tip of the shoot. Avoid terminals that have not flushed with the rest of the tree. Take leaves that are healthy and disease-free. You will need between forty and fifty leaves. Take leaves from all four sides of about 15 trees spaced throughout the block. Do not sample leaves that have been sprayed with foliar nutrients as the result will be contaminated with the residue.

Most soil samples are taken in the 0 to 15 cm zone. It is a good idea to take a sample from deeper in the profile as well to get a better picture of the nutrients available. Sometimes nutrients can accumulate at lower depths in the profile. A test between 30 and 50 cm will show what is happening lower in the soil. Sample about 10 sites in each block, using a soil auger or a spade to take the samples. Mix the samples in a clean bucket and take a subsample to send to the laboratory. If lime or other fertilisers have been applied recently, scrape the top soil away to avoid sample contamination.

A general fertiliser program

The fertiliser needs of mango trees will vary according to soil type, irrigation, rainfall, climate, cropping history and tree size. Because mango trees are large plants that are able to store energy reserves from one season to another, tree growth, health and cropping is influenced by changes to any of these over the past one to three years.

No single fertiliser program will suit all trees in all situations, however, as a general guide, the following program is a good starting point and can be refined with the use of leaf and soil analysis and orchard cropping history.

The major nutrients

In most soils mango trees require regular applications of nitrogen, phosphorus and potassium. The other nutrients that are needed on a regular basis are calcium, magnesium and boron. Table 5 lists the

quantities of each fertiliser required for three different tree sizes. The trees are divided into groups based on the size of the tree. There is a range of rates for NPK application. Use the lower figure for trees that have had a light crop and the higher figure for trees that are cropping heavily. Use the lower rates on fertile soils and higher rates on sandy soils or where heavy rain has leached nutrients.

Then follow the timing guidelines below.

Immediately after harvest

Two-thirds of the total NPK requirement is applied as soon as possible after harvest to stimulate the postharvest leaf flush. This fertiliser application should coincide with the recommencement of irrigation to move the fertiliser into the root zone and stimulate tree growth.

Two to four weeks after the first fertiliser application

The other major nutrients, calcium, magnesium and boron, are applied to the soil during the wet season. Apply the first of three boron applications after the calcium/magnesium application. If soil pH is below 6.5 you may choose to apply the calcium and magnesium as a lime/granomag blend. If trees are zinc or iron deficient, apply nutrients as a foliar spray on the new leaf flush.

Before flowering

Apply the remaining one-third of the calculated NPK requirement towards the end of the wet season between early March to early May.

A second calcium application is recommended at this time. Apply another 3.5 to 4 kg of gypsum per tree in May or June. A foliar application of a 1% boron spray (10g of Solubor® per litre of water) is applied just before flowering.

At floral bud break or early fruit set

Apply an extra potassium application of potassium sulphate. If nitrogen levels are low use potassium nitrate. Monitor leaf colour during September and apply an extra 100 g to 300 g of potassium nitrate only if the trees are looking yellow. Apply a second boron application of 0.75 g/sq. m of canopy area of Solubor® (Table 5).

Table 5. General fertiliser program for mango trees

	Canopy diameter		
	1–3 m small Keitt	**2–6 m Kent, large Keitt, Palmer, small KP, small R2E2**	**4–8 m large KP*, Haden, large R2E2**
After harvest			
NPK mixture (12:2:13)	350 – 650 g	650 – 2000 g	2000 – 2700 g
Four weeks later			
gypsum	1 – 2 kg	2 – 3 kg	3 – 4 kg
magnesium sulphate	500 g	500 g	500 g
Solubor®	10 g	20 g	40 g
Before flowering			
NPK mixture (12:2:13)	100 – 350 g	350 – 1000 g	1000 – 1300 g
gypsum	2 – 3kg	3 – 4 kg	4 – 5 kg
foliar boron	1%	1%	1%
At budbreak			
Foliar potassium nitrate	1%	1%	1%
Solubor®	10 g	20 g	40 g
potassium sulphate	500 g	1 kg	2 kg

*KP = Kensington Pride

Other nutrients

Although deficiency symptoms are rare, several other nutrients are occasionally required. Zinc and iron are the main nutrients to check. Use leaf analysis to see if the application is necessary. Apply these nutrients on the postharvest leaf flush. Zinc sulphate heptahydrate and iron chelate can be applied as foliar sprays.

Watering

Although the mango is a drought-hardy tree, water management is essential for good fruit production in most mango growing areas. The most critical period for watering is from floral bud break to just before harvest. A good water supply is also important for the postharvest flush. After the postharvest flushes have matured, withholding water from the trees will help to ensure that they enter a dormant phase. Both cooler weather and low soil moisture during winter encourage dormancy, which is very important for flower induction.

Water requirements

Flowering

Irrigation should be started at flowering. Water use while the trees are flowering is extremely high due to the increased surface area of the flowers (inflorescences).

The best time to restart irrigation is when most of the inflorescences have half emerged. The amount of water required will depend on the tree size. You should aim to keep the top 60 to 80 cm of soil moist. The total amount of water you need will depend on the size of the tree. Trees

that are 6m in diameter may use 1500 L of water each week. After flowering the water requirements reduce slightly before increasing as the fruit begins to grow. Any water stress during this period can result in heavy fruit drop.

Fruit development to harvest

Continue irrigation throughout the fruit development period until one to two weeks before harvest. Again depending on tree size and climatic conditions, up to 2000 L per tree per week may be required. Reduce watering slightly one to two weeks before the anticipated harvest date to increase fruit dry matter levels. Reducing watering sooner or cutting it off completely could result in smaller fruit and the risk of fruit splitting if it rains during this period.

Irrigation
Section 4 page 25

Regular irrigation throughout the fruit development period is essential for good uptake of nutrients, especially calcium. Throughout the fruit growth period the soil under trees should not be allowed to dry out completely between irrigations.

Postharvest vegetative growth

Mango trees require irrigation immediately after harvest to move applied fertiliser into the root zone and encourage an early vegetative flush to prepare the tree for the next crop. If growth regulators have been used the soil must be kept wet for good uptake. Irrigation to supplement rainfall should continue until one to two vegetative flushes have matured after harvest.

Dormancy

After one or two vegetative flushes have matured, irrigation should be greatly reduced or stopped to prevent further vegetative flushing and to encourage the tree to enter a dormant phase in preparation for flowering.

Table 6 shows some suggested irrigation rates for mature mango trees. These rates can vary, depending on locality, variety, plant density and soil type. Soil moisture monitoring is the best way to make sure that your trees receive the right amount of water.

Table 6. *Irrigation rates (litres per tree per week) for mature mango trees*

Time of year	Growth stage	4 m canopy diameter	6 m canopy diameter
January to mid April	Vegetative flush	400	1000
Late April to mid July	Dormancy	0	0
Late July to September	Flowering	600	1500
October to mid February	Fruit growth	800	2000
November to March	Harvest	400	1000

Pruning and canopy management

The aim of canopy management is to develop and maintain a productive fruit-bearing surface. Mangoes flower from the tips of branches (apical flowering). If these tips are pruned off in winter, mangoes can also produce flowers from leaf buds (axillary flowering) just below the tips. This means that the more terminal branches a tree has, the greater the possible yield. However, a tree that has very dense foliage is harder to spray, so growers must balance fruit bearing potential with ease of management. Better light penetration also assists fruit colour development. Early pruning after harvest can also help to synchronise shoot growth to achieve more uniform flowering.

Trees that have had a heavy crop can be slow to flush after harvest and the flush is often uneven. Slow postharvest flushing can delay the carbohydrate energy build up which supports the next season's crop. Uneven flushing results in a canopy with a spread of shoot ages that leads to a spread of flowering in the following season.

An ideal tree has an open canopy, is small enough to pick easily and has many fruiting terminals. This can be achieved by pruning and the use of chemical growth regulators.

In summary, mango trees are pruned to:

- control tree size
- maintain an open tree to improve spray and light penetration
- maximise fruiting terminals
- improve fruit colour
- synchronise and encourage flushing
- remove dead and diseased wood
- make it easy to use machinery under and around the tree.

Trees can be pruned by hand or mechanically.

Hand pruning

Hand pruning techniques will vary, depending on the variety grown and the tree's condition. Pruning is best done each year immediately after harvest. This involves the following steps:

1. Cut back branch terminals to behind a growth node. Remove all but two or three well-spaced shoots from branch tips. Keep the trees to a diameter that allows machinery to travel between the rows and allows trees to just touch within the rows.
2. Cut upward growing branches at a height of 4 to 4.5 m.
3. Remove any low growing branches that are likely to interfere with under-tree access or watering.
4. Open up the interior of the tree by removing some of the branches where growth is crowded. Remove shoots that are not exposed to sunlight. Thin out the canopy in dense trees to allow spray penetration and to improve light penetration and air circulation.

5. To maintain tree size and encourage a well branched canopy, branches should be cut back behind a node. This is particularly important for varieties that have strong apical dominance such as Keitt and Brooks. The branches on these varieties must be cut back regularly to improve tree shape.
6. Remove dead or diseased branches and dead inflorescences.
7. Paint the top side of all exposed branches with white water-based or plastic paint to prevent sunburn.

A light secondary pruning can be done in late April or May, at the beginning of the winter dormancy period, to remove internal sucker growth.

Mechanical pruning

Pruning costs can be greatly reduced if you use mechanical saws. These saws are mounted on a tractor and can be set to cut at any angle or height. Usually only the tip growth is removed. Trees that are mechanically pruned have a square or rectangular shape, with the four sides and the top trimmed flat (Figure 16).

Some hand pruning is still necessary after machine pruning, particularly on the inside of the tree.

Figure 16. *Mechanical pruner/tractor*

Propping fruiting branches

Despite your best pruning efforts, some trees will require extra support for branches that are heavily laden with fruit. Fruit that touch the ground are unsaleable as they develop blemishes and rots from rubbing on the soil. Varieties such as Keitt and Brooks which have a lanky growth habit and long inflorescences, often require support, particularly when the trees are young (Figure 17).

Figure 17. *Young Keitt tree with supports*

The most common system for support is a single stake about 1 m long with a hole in the top to which you can tie the branch. Support each branch with an individual stake. The supports will need to go on to the branches when they start to hang down from the weight of the fruit. This will be as the fruit starts to size up four to five weeks before harvest.

Growth regulators

Chemical growth regulators are used for canopy management in mangoes. The most commonly used growth regulator is paclobutrazol, sold as Cultar®.

It is mainly applied to the trees to induce flowering, but it has a positive side effect in reducing the size and number of vegetative growth flushes. This helps to build up carbohydrate reserves before flowering, which results in stronger more consistent flowering, leading to a higher yield. The other benefits are earlier flowering and less crowding of the canopy as trees take longer to fill the space available.

Treated trees can flower up to three weeks earlier than untreated trees. This early flowering is undesirable in the cooler subtropics where temperatures around flowering can be too cool for successful pollination. The growth regulator acts against the naturally occurring plant hormone, gibberellin, and reduces the length of shoots. It is the restriction of growth that lets the tree direct more energy into carbohydrate storage.

Mangoes at tropical latitudes that have a short dormant period in winter benefit most from Cultar®. Trees in cooler, subtropical areas tend to have stronger and more regular flowering, with earlier flowering seen as a disadvantage with respect to fruit set.

When should you apply Cultar®

Once tree canopies are more than 3 m in diameter you can start using Cultar® as part of your management program. Cultar® should be

applied within four weeks after harvest, before vegetative flushing starts.

Rate

The rate of Cultar® to apply is determined by tree size and soil type. Experience on soils other than sand shows that the best rate per tree is 1 mL of Cultar® per square metre of canopy area. Sandy soils require a slightly lower rate.

The canopy area is calculated by multiplying the tree height in metres by the canopy width, also in metres. For example, a tree 4 m high and 4 m wide has a canopy area of 16 sq. m. The rate of Cultar® would be 16 mL per tree for a loamy soil. In a sandy soil use 12 mL per tree or 0.75 mL per square meter of canopy area.

How to apply Cultar®

Dilute the Cultar® in enough water to ensure an even distribution around the trunk. This will give an even distribution of the chemical throughout the tree. It is best to use a minimum of 1 L of water and apply the solution around the trunk at a height of 20 cm above the soil (Figure 18). Endeavour to keep the solution as close to the trunk as possible.

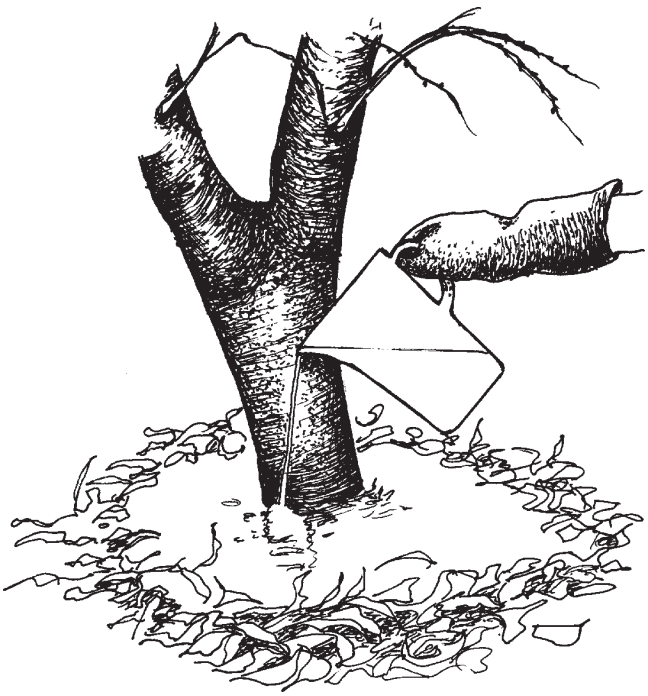


Figure 18. *Method of applying Cultar® to a tree*

Cultar® is absorbed mainly through the bark of the large roots. The soil must be wet for several weeks around the treated trees to maximise the rate of uptake. It is also advisable to remove all weeds before its application to avoid uptake by weeds.

Special considerations

Trees need to be actively growing to absorb Cultar®. Do not use Cultar® on trees suffering from disease or any other stress, such as drought, salt, waterlogging or frost.

If the rate of Cultar® is too high, inflorescences are likely to become tight and compact. If this occurs they can harbour flower eating caterpillars and predispose the flowers to diseases such as anthracnose and powdery mildew, so additional sprays may be necessary.

Cultar® can be used every year. Adjust the rate depending on the flowering response from the previous year.

Pest and disease management

The essential components of an effective pest and disease control program are:

- regular calibration and set-up of sprayers to ensure that each tree

receives the correct volume of spray and that the whole tree receives good even coverage
- pruning to allow penetration of sprays into the canopy
- routine orchard monitoring based on a good understanding of the pests, their life cycle, crop stage and the weather
- knowledge of pesticides, their appropriate rate and safe use.

The pests of mangoes are described in detail in the DPI publication *Mango pests and disorders.*

Advice on sprayer calibration is available from chemical resellers or DPI offices. Growers will need to obtain chemical accreditation to buy and use some chemicals. The ChemSmart accreditation course will also cover spray calibration and the principles of chemical use. It is a legal requirement that you only use chemicals that are registered for use on mangoes and that you observe the withholding periods specified on the label. Spray equipment must be well maintained and calibrated regularly. The *Pesticide application manual* available from DPI, gives information on sprayer calibration and how to adjust your sprayer to give good coverage of trees.

ChemSmart
Section 6 page 7

Insect and mite pests

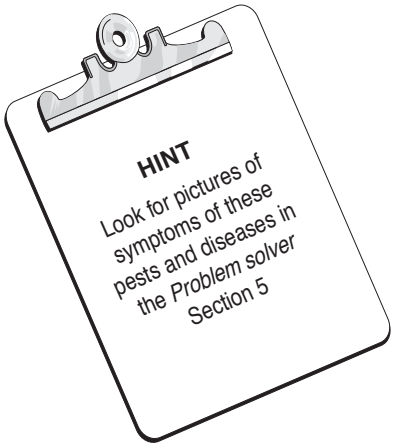
Proper identification and early intervention are essential for successful insect pest management. Pests can be managed by a mixture of appropriate cultural methods, natural predators and the strategic use of pesticides. The overuse of pesticide can result in the pest developing resistance, further adding to costs. Some pesticides affect beneficial insects too, so their overuse can result in the build up of other pest problems. Regular monitoring, careful pesticide selection and good timing are the keys to good pest management with minimal adverse side effects.

Problem solver handy guide

Major pests

Mango scale

Mango scale is a widespread and a serious pest in mangoes. Females are round, while males have a rectangular white covering. They feed on plant sap and infested areas on leaves turn yellow and die. Heavy infestation on stems can result in stem death. Infestation on fruit causes a distinctive pink spot, which will downgrade fruit quality. Heaviest infestation generally occurs inside the tree on the shadiest areas. The female lays eggs under the round scale covering and when they hatch the young scales (crawlers) move to a new feeding site. The critical times to control mango scale are when the young crawlers are most active. This is usually from September to late November and after harvest. The postharvest treatment should be applied after pruning to improve coverage.



Fruit fly

Fruit flies are major quarantine pests that are more active during the hot and humid wet season. Because some late varieties mature during this period, they are most at risk from fruit fly attack and may require stringent control measures.

Adult female flies sting the fruit to lay their eggs. Bacteria introduced with the eggs start to rot the fruit and the larvae feed in the decomposing flesh.

If you are following the interstate certification arrangement ICA-19, which includes field spraying for fruit fly control, you will need to apply a minimum of three cover sprays in the six weeks before harvest.

Mango planthopper (flatids)

Planthoppers only cause minor direct damage from their feeding on shoots, leaves and fruit. The more severe problem is from the growth of sooty mould that develops on the exudate produced by these sucking insects. Egg pods and nymphs are covered in a white powdery excretion. Both nymphs and adults jump when disturbed.

Fruitspotting bugs

Usually not a severe pest of mango, fruitspotting bugs can cause significant damage, especially where other susceptible crops are grown near mangoes. Bug feeding on very small fruit can result in fruit drop and feeding on the tender new shoots will result in severe cracking of the shoots and distortion and wilting similar to tip borer.

Helopeltis

A bug that causes damage similar to fruitspotting bug is *Helopeltis* or tea mosquito bug. The stings from this bug are smaller and more numerous than from fruitspotting bugs and the damage occurs on very young fruit soon after fruit set.

Mango seed weevil

Mango seed weevil can be an important pest because it is a quarantine pest for some export markets. The insect causes only minor blemish on the fruit skin but the larvae feeding within the seed destroy the cotyledons, making it unviable.

Mango shoot caterpillar

The larvae of mango shoot caterpillar feed on the new flush leaves and can severely set back the growth of young trees. The post pruning flush in January and February is most at risk.

Mango tipborer

Mango tipborer larvae tunnel through the newly developed shoots, causing wilting and shoot death. Loss of terminals can reduce yield and restrict development in young trees.

Flower eating caterpillars

Flower eating caterpillars can be a problem when flowers are heavily compacted after use of growth regulators.

Minor pests

Pink wax scale

Conspicuous pink wax scale insects can cause severe sooty mould development on leaves, giving trees a blackened appearance.

Redbanded thrips

Severe infestations of redbanded thrips can cause silvering on the underside of leaves. Fruit can also be damaged.

Mango leafminer

Leafminer larvae feeding below the leaf epidermis of newly developed leaves give the upper leaf areas a blistered appearance. Damage is usually confined to young trees. It is becoming a major pest in Mackay, Bowen and some parts of the Burdekin. It causes severe damage to young foliage and new shoot growth. All ages of trees are affected.

Fruitpiercing moths

Adult fruitpiercing moths feed at night and pierce the skin of ripe fruit with their strong proboscis. Juices are sucked out and the internal injury resembles a honeycomb.

Tea red spider mite

Usually controlled by predatory mites and other predators, the presence of tea red spider mites generally indicates an overuse of pesticides. Damage is confined to the leaf tissue adjacent to leaf veins.

Mango bud mite

Rarely a problem in commercial plantations, mango bud mite causes stunted development and terminal malformation in neglected trees.

Monitoring for insect and mite pests

A program of routine calendar sprays is not recommended because:

- It is a waste of money if the pests are absent.
- Even when pests are present, it disregards the fact that plants can tolerate small numbers of pests without significantly affecting yield and quality. In these cases, the cost of spraying is much greater than the benefit gained by controlling the pest.
- It can kill many of the beneficial predatory insects that naturally keep pest populations under control.
- It increases the risk of chemical burn to the fruit.
- It increases the amount of chemical residue in both the fruit and the environment.
- It provides a greater risk of pests developing resistance.

A better approach to insect control involves checking the crop regularly to determine when pests are present. Only when they are present and at damaging levels, are chemicals or other control measures applied. The systematic process of checking the crop for the presence of pests, their damage, and the presence of beneficial species to determine the need for control, is called monitoring.

The system is based on predetermined pest action levels or economic thresholds. These levels indicate the pest populations at which damage is roughly equivalent to the cost of control.

With crop monitoring, pest levels are measured and compared with the action levels. Control measures are applied only when pest populations approach or reach these action levels. Monitoring then continues to manage pest populations at or below this action level.

The beneficial insects and mites that naturally attack the pests are also monitored. In some cases, they are sufficient to keep the pest populations in check without additional chemical controls. Most of the threshold or action levels for the major insect pests of mangoes have not yet been established. Table 7 gives a guide to possible threshold levels.

Table 7. *Pest monitoring schedule and a guide to action levels for mangoes*

Pest	How to monitor	Possible action levels
Mango scale	Check five leaves or fruit from 20 fruit trees in each 5 ha block. Leaves must be less than 12 months old.	If more than 25 leaves have more than one mature female or three immature female scales.
Fruit fly	Use Dak pots or fruit fly traps. Monitor the number of fruit flies caught each week when the weekly fruit are three-quarters grown onwards.	When numbers increase significantly, apply either a fortnightly cover spray or bait sprays using chemicals from the *Problem solver handy guide*.
Flower eating caterpillars	Inspect two inflorescences from 20 trees in each 5 ha block.	Only apply sprays if whole inflorescences are being destroyed. Apply any insecticides in late evening.
Mango planthopper (flatids)	***Nymphs or egg pods*** Check five leaves from 20 trees.	Spray if more than 20 stalks (one in five) have one or more planthoppers.
	Adult planthoppers For every 5 ha of orchard, check five fruit stalks from 20 trees.	Spray if more than 20 stalks (one in five) have one or more planthoppers.
Mango tipborer	Monitor young vegetative shoots. Mature trees can cope with a reasonable level of shoot death without affecting yield.	Spray if any damage is observed on young trees.
Mango seed weevil (for quarantine markets)	Monitor the skin of fruit from early fruit development (pea size) until three-quarters grown for the presence of larvae.	If more than five larvae/eggs are found, apply two sprays 14 days apart.
Fruitspotting bug	Monitor the skin of fruit from early development (pea size) until three-quarters grown.	Spray if any damage is observed.

Growers can develop their threshold levels themselves or in consultation with a pest consultant. The key is to keep detailed records of pest infestation levels and estimate the level of yield loss that is occurring. You can estimate some yield loss from reject analysis in the packing shed.

It is much more difficult to estimate yield loss from damage to shoots or flowers before harvest. This is because trees are able to compensate for this early damage with lower fruit drop or even by putting on a secondary flowering or flushing. For monitoring, you need a x10 hand lens and a pin or needle to turn over scales to check if they are alive.

Diseases

The approach to disease control is different to that for insect and mite pests. As disease organisms are microscopic, they cannot be seen and their arrival and build-up in the crop cannot be as easily monitored. In most cases, disease control requires routine preventative spraying to protect the crop from possible infection. The major diseases controlled through spraying are anthracnose, stem-end rot, mango scab and bacterial black spot (which damage fruit and shoots), and powdery mildew (which affects flowers). A broad program for disease control is in the *Problem solver handy guide*.

Disease control
Problem solver handy guide

Anthracnose

Anthracnose is a fungus that affects most parts of the mango tree. It grows on leaves, young shoots, flowers and fruit. The fungus spreads from spores that are produced on dead twigs, branches and leaves. These spores are spread by water splash onto new growth. Infection on the flowers and young fruit can cause severe flower and fruit drop, but on larger fruit the infection can lie dormant until the fruit starts to ripen, when the fungus develops into large black areas. Infection can be controlled by protectant sprays. During flowering, spray fortnightly with a protectant fungicide. If wet conditions occur during flowering (more than two to three wet days), use a systemic fungicide in place of the protectant to provide better control. Between fruit set and harvest apply the protectant spray every 14 to 28 days. Use the shorter interval if the weather is very humid or if it rains.

Stem-end rot

Stem-end rot is caused by several fungi. The main one is *Dothiorella dominicana*. The fungus is a natural inhabitant of the mature branches of the mango tree. The fungus colonises new growth as it matures and it grows into the stem end of the fruit before harvest. The fungus develops in the fruit and the typical brown decay starts at the stem end as the fruit ripens. Water stress is believed to favour the development of this disease. Infection can also occur from spores landing on the fruit from dead twigs and bark. This infection results in small spotty lesions all over the skin of the fruit. This type of infection is more of a problem

in wet weather. In fruit from drier areas stem-end rot may be more serious than anthracnose. To keep this disease under control, keep the trees healthy and well watered during fruit growth. Postharvest fungicide application is the main chemical control method.

Mango scab

Mango scab is becoming more serious in Queensland and any suspected outbreaks should be reported. The disease will affect leaves, stems and fruit. Applications of fungicides during fruit development have been effective in giving control. Spraying with a protectant fungicide during vegetative flushes will protect new leaves.

Bacterial black spot

Varieties such as Keitt and Kent are more susceptible to bacterial black spot than Kensington Pride. Bacterial black spot develops during wet windy conditions. It will affect fruit and leaves all year round.

The disease is a weak pathogen and can only colonise damaged tissues, new leaves and young fruit. The primary defence against this disease is to control wind damage to trees as abrasions on leaves, shoots and fruit are ideal entry sites. A reduction in infection sites significantly lowers disease pressure and the disease can then be effectively controlled with a program of protectant fungicides. Spraying should continue at regular intervals for at least two years until all the old infected tissue has fallen from the tree.

Bacterial black blight

In the 1999 flowering season, a new disease of mangoes was found in the Bundaberg region. The symptoms appear on the flowers and include blackening on the surface/epidermis of the inflorescence axis, discolouration of the vascular and pith tissues and, in advanced cases, dying back of the inflorescence from the tip. This results in poor or no fruit set on infected inflorescences. Similar symptoms have been found at Cooroy, Gin Gin, Childers, Bundaberg, Avondale, Gatton, Pomona and Kandanga. Symptoms have not been detected in the central and northern growing areas of Queensland.

The most susceptible variety appears to be Kensington Pride though symptoms have also been found in the varieties Nam Doc Mai, R2E2 and Keitt.

The bacterium *Pseudomonas syringae* has been consistently isolated from affected inflorescences. Different pathovars (strains) of this organism cause bacterial disease in a range of crops including soybean, cucurbits, pea and bean. The pathovar causing the disease in mangoes is unknown and more detailed studies are needed. A similar disease of mangoes in Israel caused by *Pseudomonas syringae* is referred to as bacterial black blight. Work has started to determine the cause and control methods for this disease.

Powdery mildew

Powdery mildew is favoured by very dry weather conditions, which can occur when mangoes are flowering. It affects the inflorescences, causing damaged flowers and small fruit to shed. When older fruit are infected purplish-brown, blotchy, chapped or russetted areas develop on the skin.

Fruit disorders

Disorders are caused when the normal metabolism of the fruit is affected. Some common fruit disorders of mango include internal breakdown, stem-end cavity, jelly seed and soft nose. Although all of the contributing factors to these fruit disorders are not known, calcium and nitrogen nutrition and crop load play a role in their development. Excessive vigour from too much nitrogen applied during fruit growth and deficiencies of boron and calcium in the fruit contribute to the problem. The incidence of internal disorders increases as fruit maturity advances on the tree.

Varieties vary in their susceptibility to fruit disorders. Pick fruit as soon as it is mature to minimise breakdown problems. Internal breakdown in Keitt is most common on trees that have a light crop. If you have very large fruit that is dark green, it is more likely to suffer from the disorder. If you believe that internal fruit disorders could be a problem in your orchard, check five fruit from each tree for symptoms of breakdown before you start to harvest. Do not pick fruit from trees where breakdown is found.

Vertebrate pests

Although birds and fruit bats can devastate a crop, depending on seasonal conditions and location of the orchard, most growers do not need to control these pests. Late varieties, or fruit that is left to ripen on the tree are more prone to damage. Bird kites, scarecrows and light and sound generators have been used to frighten these pests and they are somewhat successful when pest levels are low. Once bird and fruit bat numbers increase, artificial scaring devices fail.

Bagging fruit

Some growers have been experimenting with bagging individual fruit. Light-coloured, water-resistant paper bags are placed over the fruit after fruit set. Bagging protects fruit against sunburn, diseases and blemishes and produces an even fruit colour and blush. However, effective pest control measures must be in place before bagging to prevent the build-up of pests, such as mealybugs, inside the bags. Bagging fruit is labour intensive. It is only feasible in small orchards where high quality fruit is being sought, or in organic growing operations where chemical use is minimised.

Several growers have reported fruit damage, particularly scalding, after using bags. Fruit normally scald only when the wrong type of bag is used.

Weed control and mulching

Weed control in young trees
This section page 19

Continue the mulching and spraying program outlined under *Looking after young trees*.

Harvesting and postharvest handling

To supply a quality product, growers have to pay particular attention to harvesting and postharvest handling of mangoes. There are 18 key steps.

Recognising maturity

Fruit is harvested in a green mature state so that it can be packed and delivered to market before it ripens and becomes too soft. To achieve good flavour and appearance, mangoes must be fully mature before harvesting.

Fruit is mature when the:

- the flesh of Kensington Pride fruit has a minimum of 14% dry matter

- flesh colour of Kensington Pride fruit is showing yellowing as described for Stage 3 in the DPI's *Mango picking guide*
- beak-end of the fruit fills out and feels smooth, and the shoulders of the fruit lose any wrinkling
- background colour of the fruit changes from distinct green to pale green
- blush colour of the fruit brightens
- fruit separates easily from the stalk, and at advanced maturity exudes less sap.

All of the mangoes on a tree don't mature at the one time. The first pick usually yields few fruit and may result from an odd, early flowering branch. You may need two or three picks to harvest the orchard.

Harvesting

Mangoes must be harvested and handled very carefully as the fruit is easily damaged during handling. Skin can be damaged by rough handling and by contact with mango sap. This is particularly the case for Kensington Pride, while there is less of a sap problem with other varieties. When the stem of a mango is removed close to the fruit, a highly caustic sap is released. The first sap released is called **spurt sap** because of the way it spurts out as soon as the stem is removed. The release of this sap is referred to as desapping. If this sap contacts the fruit it will damage the skin. Symptoms range from small dark spots to dark sunken blotches. These sapburn symptoms do not usually appear until 48 hours after the damage is done. The fruit will be downgraded from Class 1 to Class 2 and the value of the fruit is reduced. Consumers commonly mistake this unsightly blemish from sapburn as a fruit rot, and in severe cases the fruit may be unsaleable.

Sapburn and skin browning
Section 4 page 48

Sap will continue to exude from the fruit for some hours after desapping. After the initial spurt of sap (about 30 to 60 seconds), the composition of the sap changes. This secondary sap release is referred to as **ooze sap**. It is not as damaging as spurt sap but it can still cause skin browning symptoms if it stays in contact with the fruit for a longer time.

Fruit must be harvested and handled to minimise damage to the skin from contact with sap. The sap can also burn the skin of pickers and desappers; some people are very sensitive to mango sap and they should protect their skin when handling mangoes.

Harvesting systems

There are two main systems for harvesting and handling mangoes to minimise sap contact with the fruit.

Picking with stems and desapping in the packing shed

This system involves cutting the fruit off the tree with 10 to 20 cm of stem attached. This small amount of stem prevents sap release. The

fruit are then carefully placed in plastic crates or bins and transported to the packing shed. Secateurs are used to cut the stems. An anvil secateur with a rounded point is suitable. For fruit higher in the tree special secateurs attached to poles are used (Figure 19). These secateurs can cut and hold the stems at the same time so that pickers from the ground can reach fruit at the top of the tree. Keep the crates in the shade as fruit can get sunburnt if they are left in the sun after picking.

Figure 19. *For fruit higher in the tree, special secateurs attached to a pole, can cut and hold fruit at the same time*

Great care must be taken in handling and transporting this fruit. If the stalk is broken, sap will exude over the fruit in the crates or bins and cause sapburn.

Once in the packing shed, the fruit are dipped or sprayed with a solution of detergent or wetting agent before destemming by hand. It is important that the fruit are well covered in the solution before the stem is removed. When destemming by hand the fruit is held with the stem end down as the stem is pulled off to direct the sap away from the fruit and the desappers hands. This should direct the spurt sap into a sap receptacle and away from other fruit and the machinery. The desappers should take special care to avoid getting sap on their hands as the sap can burn the skin and sappy hands will cause burn on fruit. The fruit are then placed stem end down under a continuous spray of water onto moving racks for up to an hour. The water sprays are only over the first third of the rack, the remainder is to allow most of the water to dry before the fruit go into the hot dip. This process washes the detergent off and allows some of the ooze sap to drain away.

Desapping in the field

Harvest aids are machines that have recently been developed to pick, destem and desap fruit in the field, in an attempt to reduce sapburn and harvesting costs. Various designs are available and all have reduced harvesting costs by as much as 40% and greatly reduced sapburn. Care must still be taken to avoid skin browning which can occur in this handling system.

The basic design of these machines is a trailer fitted with tightly stretched canvas that is often referred to as a trampoline (Figure 20).

A detergent solution is continually sprayed on to the trampoline. With this system, fruit are picked without stems and dropped onto the trampoline, where they are immediately covered in the detergent solution. The rapid covering of fruit with detergent solution helps to protect them from sapburn. Fruit then roll to a collection point where the detergent may be washed off before the fruit are placed in plastic crates or bulk bins and delivered to the packing shed, where they are loaded on the packing line.

Figure 20. *Typical mango harvest aid*

This handling system can also be adapted for use in a packing shed. Fruit are picked and brought to the shed with stem attached. They are desapped and placed in a dip containing a detergent solution. Fruit stay in the dip for one to two minutes before they are placed on the packing line.

Which detergent solution to use?

The choice of chemical solution followed by thorough washing of the fruit is important to the success of desapping.

Picking with stems. The fruit is covered with detergent before the stalk is removed to prevent sap directly contacting the skin. As the fruit are placed on the packing line water sprays remove the detergent and any sap residue. The best choice in this situation is a detergent such as Cold Power® or LOC or a wetting agent such as Agral®. The mixing rate is 1 mL or 1 g per litre of water. Staff who desap fruit must keep their hands clean of sap as a lot of sapburn has been attributed to 'sappy fingers'.

Harvest aids or desapping into a detergent solution. These handling systems leave sap residues on the fruit and a neutralising additive such as Mango Wash® or hydrated lime is the most effective chemical for the wash solution. Mango Wash® is a neutraliser and detergent mixture and needs no additives. When hydrated lime is used, it is mixed with a detergent such as Agral®. The mixing rate is 10 g of hydrated lime with 1 mL of Agral® per litre of water. This detergent mixture is washed off at the start of the packing line or on the harvest aid.

The mango packing shed

In mango packing sheds there is a common sequence of operations, though some of the treatments applied will depend on the postharvest pest and disease controls required (Figure 21).

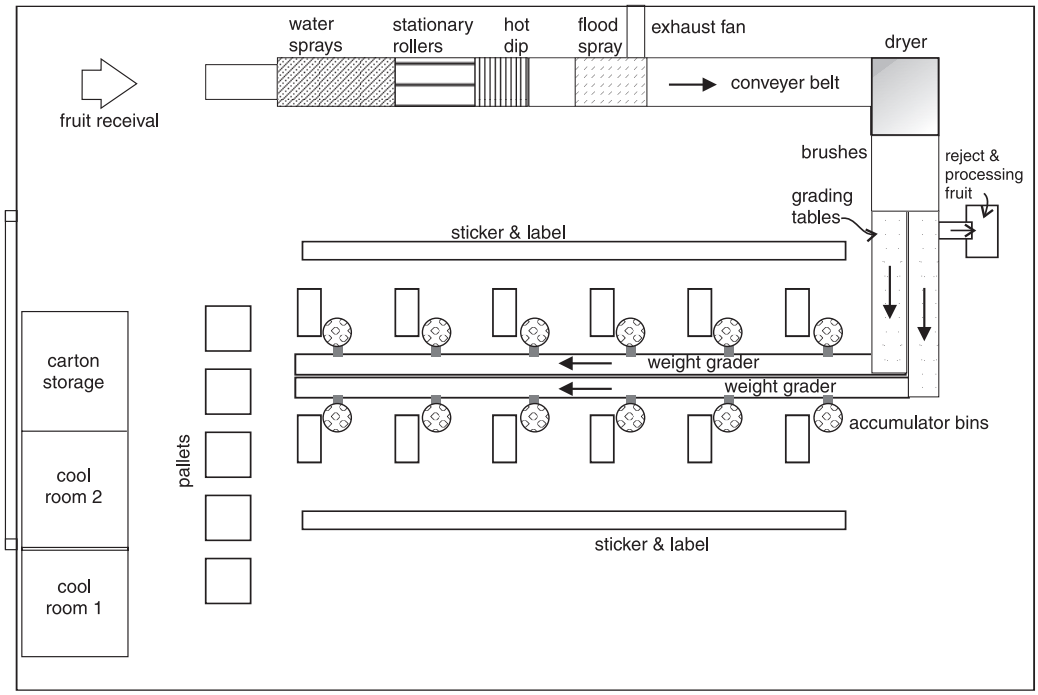


Figure 21. *Typical layout for a mango packing shed*

Mangoes are extremely sensitive to skin damage and the handling system must be designed to minimise this damage. The main causes of damage on the packing line are bruising and abrasion from rough or dirty surfaces, scalding and sap contamination. To minimise bruising, mangoes should not fall more than 300 mm. All packing equipment should be cleaned daily, while areas that are prone to sap and dirt collection should be cleaned at lunch time as well as at the end of the day.

Receival inspection

When fruit arrives at the packing shed a quick check can alert you to any problems that could arise during packing. It also provides a check that pickers are picking fruit correctly. If immature fruit or cuts are found during the receival check, you can quickly inform the picking crew that they need to do a better job and let your graders know what they can expect. This will help them to do a good job grading the fruit.

Loading fruit onto the packing line

The way the fruit is loaded depends on how it is picked and desapped. If the fruit is being desapped in the shed it will be placed either onto the racks stem down by hand or put into a detergent dip. Fruit loaded on these racks is washed and allowed to drain as it moves slowly towards the hot dip. Fruit desapped into a detergent dip or onto stationary racks is placed into crates and tipped into a hopper, from where it is washed over brushes before going into the dip.

Fruit from harvest aids is also tipped into a hopper for loading on to the packing line.

Postharvest disease and fruit fly control

Postharvest diseases can ruin an otherwise high quality crop. The best control of these diseases is through a combination of preharvest and postharvest fungicide application, orchard hygiene and postharvest temperature management. The postharvest treatment will not replace lack of care in the field.

You must be particularly careful with fruit that is to be cool stored or kept in controlled atmosphere storage. Disease development increases the longer fruit are held in storage. Holding fruit at temperatures of 25°C and over increases disease development.

Anthracnose

Anthracnose (*Colletotrichum gloeosporioides*) is very common in most mango growing regions but it is more of a problem in wetter areas. The fungus remains dormant on green fruit until it begins to ripen. As the natural resistance of green fruit breaks down, the fungus can grow unchecked unless postharvest treatments to control the disease are applied. There are two main treatments available. A hot dip using carbendazim (Spin flo®) or a flood spray with prochloraz (Sportak®). Your choice of treatment depends on the level of disease in the orchard and the incidence of the other major fungus, stem-end rot. If stem-end rot is not a problem, you can treat with prochloraz alone; if it is a problem, you will need to use a hot carbendazim dip.

Stem-end rot

Stem-end rot is caused by several fungi. The main one is *Dothiorella dominicana*. The fungus occurs naturally in the mature branches of mango trees. The fungus colonises inflorescence tissue and reaches the stem end of fruit several weeks after flowering. Depending on conditions it may grow into the stem end of the fruit before harvest. The fungus develops in the fruit and the typical brown decay starts at the stem end as the fruit ripens. Water stress during fruit development and maturation is believed to favour the development of this disease. Infection can also occur from spores landing on the fruit from dead twigs and bark. This infection results in small spotty lesions all over the skin of the fruit. This type of infection is more of a problem in wet weather. In fruit from drier areas stem-end rot may be more serious than anthracnose.

Checking the stem-end rot status of the orchard

In young orchards the incidence of stem-end rot is less prevalent, particularly if leaf litter and prunings are not allowed to accumulate. You can check the prevalence in your orchard in the following way. Harvest 100 mature fruit at random throughout the orchard. Leave the fruit completely untreated and store at 25°C until they are fully ripe.

No more than one-third of the fruit should develop stem-end rot symptoms by the time they are fully ripe. If there is more breakdown than this, the orchard has a severe problem and you will need to look at improving preharvest practices. If the incidence is less than 10% you may be able to get away without using the carbendazim hot dip.

Other postharvest diseases

A few other fungi can cause fruit losses during storage, but the incidence is not common. To minimise the risk of infection from these diseases, carry out good shed hygiene that includes the regular removal of reject fruit from the shed and regular cleaning of all equipment.

Treating fruit with a hot dip

For stem-end rot and anthracnose control, fruit must be immersed for five minutes in a heated solution of carbendazim at 52°C.

This is done in a specially designed tank in the packing line. The tank is heated by gas or electricity and the contents are kept agitated with a powerful recirculating pump. This agitation keeps the fungicide evenly mixed and helps to distribute heat from the heating element. The size of the tank should be big enough to allow 3 L of dip to each kilogram of fruit, so there is no appreciable drop in temperature in the tank when the fruit is added. If done correctly this treatment will provide effective control of postharvest diseases.

During the day the volume of the dip will drop and the chemical will be stripped as fruit passes through. This means that the dip must be topped up during the day. To top up add an extra one-third of the original quantity of chemical into the dip at the halfway point of the day.

There are three points to note when dipping fruit.

Timing

The total dipping time should be five minutes. Fruit should be dipped within 24 hours of harvest but no sooner than four hours after harvest. If treatment is delayed for more than 24 hours, control is not as effective. Fruit that has just been harvested is more susceptible to heat injury.

Temperature

Fruit must be treated at 52°C. This temperature must be carefully controlled. If the temperature is lowered the treatment will not be as effective and if the temperature is higher there is a greater risk of fruit damage from scalding. During wet weather fruit becomes more susceptible to heat damage. In this case the temperature may be reduced to 50°C, but this will also reduce disease control.

Dip cleanliness

As fruit passes through the dip the water will become contaminated with sap and dirt, even if fruit has been desapped and washed. It is advisable to replace the dip every two or three days or after every 4000 trays.

Treating fruit with a flood spray

An alternative treatment for the control of anthracnose alone, is a low volume non-recirculating spray with prochloraz at ambient temperatures. Complete coverage of the fruit is essential for effective control. Prochloraz is not effective against stem-end rot, so you should only choose to use this treatment if you know that stem-end rot is not a problem in your orchard.

It is best to apply both treatments for fruit that is going to be cool-stored or transported for long distances.

Treating for fruit fly

Insecticide dips or packing line sprays are available to control fruit fly. Mangoes destined for sale in Victoria, South Australia, Tasmania and the Murrumbidgee irrigation area of New South Wales must be treated for fruit fly before consignment. The insecticide treatment may be combined with fungicide in a non-recirculating spray system.

In adition, mangoes to Victoria and South Australia must be subjected to an approved ICA arrangement which uses a systems approach to provide an adequate level of further security against Queensland fruit fly. A systems approach includes an approved preharvest treatment, postharvest inspection and postharvest treatment. Treatment may be applied as:

- **Dip**. Fully immerse fruit for 60 seconds.
- **Flood spray**. 16 L /min/sq m coverage of fruit for minimum of 10 seconds, and remain wet for a further 60 seconds.
- **Low volume non-recirculated spray**. 1.2 L/min/sq m coverage of fruit for 10 seconds and remain wet for a further 60 seconds.

The treatments must be applied in certified packing sheds. Certification procedures are available from Interstate Certification Assurance officers based at DPI offices throughout Queensland's main mango growing areas. They involve calibration of the application equipment and analysis of the chemical solution to ensure that the application is correct.

Hot water dips or vapour heat treatment are alternatives to chemical application. Fruit must be conditioned with heat before entering a hot water dip. Preconditioning gives the fruit a better tolerance of the high temperature needed in the hot water dip. It is very easy to scald fruit with this treatment so it is rarely used. The vapour heat treatment is

used for export to Japan. The equipment is very expensive and export inspectors must oversee the treatment.

Drying and brushing fruit

Fruit must be dried after postharvest treatments and before packing. Fruit packed wet will suffer from skin browning. Fruit is dried either under fans mounted over rollers or in a heated drying tunnel. The tunnel is heated no higher than 40°C.

Fruit are usually brushed after drying to give a brighter appearance. Brushes are one source of skin browning, particularly if they are allowed to wear and become stiff with dirt and sap. Do not let the fruit stay on the brushes for longer than a minute.

Sanitation of packing equipment

Equipment should be cleaned daily with a steam cleaner or high pressure hot water applicator. Otherwise use a hose with a suitable detergent. Equipment where dirt and sap collects should be cleaned at lunch time as well as at the end of the day. If you are having a problem with fruit rots other than anthracnose or stem-end rot, you may need to sanitise the equipment. Sanitation is not required on a regular basis. To sanitise the equipment use a solution that is approved for use in a food business. Be careful with concentrates and avoid inhalation.

Grading

Grading for defects is the most important operation in the packing line and requires knowledge and experience. Staff scan fruit moving past them on rollers and separate fruit into different grades according to the level of blemish and other visible defects on each fruit. Graders should keep a close eye for defects (cuts, bruises, over ripe fruit, fruit rots or disorders) that will affect the eating quality of the fruit.

There are three types of defects:

- **Quarantine defects:** defects or pests that are prohibited by inter-state or importing markets.
- **Major defects:** defects that affect the soundness of the fruit, such as wounds and fruit rots.
- **Minor defects:** defects that only affect the appearance of the fruit without affecting eating quality.

Fruit with quarantine or major defects should be rejected.

Grade standards

Mangoes are typically graded into various classes that are distinguished by the levels of minor defects on the fruit. A full colour *Mango grade standards* poster detailing standards suggested by the mango industry is available.

Where to get this poster
Section 6 page 24

Growers typically pack a range of standards, for example Extra or Premium, Class 1 or Class 2. Fruit with excessive external blemishes may be sold as processing grade fruit. Defect levels determine whether the fruit is classed as Extra, Class 1 or Class 2. An allowance is the amount of defect allowed on a single piece of fruit. For instance the allowance for blemish for a Class 1 fruit may be 1 sq. cm.

Growers should set their own grade standards. Check that your wholesale agent or retail customer agrees with your standards. Some customers have set standards for mangoes and will expect you to pack to their standard. If you don't know where to start, negotiate a set of desired standards with your intended customer.

Sizing

Fruit is sized before packing so that each packed tray will consist of similar sized fruit. This is important for appearance and to aid packing.

Fruit is normally sized mechanically using a weight grader (Figure 22). A packed tray of Kensington Pride holds between 6.5 and 7 kg of fruit. Trays of R2E2, which is a larger and rounder fruit, can weigh up to 8 kg. The approximate weight of each size of fruit is determined by dividing the weight in the tray by the count. There will always be some variation in the weights in a tray. The most important thing is that each tray of fruit is tightly packed and full. The different sizes are recognised by their count or the number of fruit that fit into a single layer tray. The larger the count, the smaller the fruit size. The average fruit weight for the main sizes are shown in Table 8.

Figure 22. *Weight grading*

Table 8. *Average fruit weight range for different counts of Kensington Pride (using 6.5 – 7.4 kg tray net)*

Count	Fruit weight (g)
16	406 to 463
18	361 to 405
20	325 to 360
22	295 to 320

Packaging and labelling

Mangoes for the domestic market are packed in a single layer fibreboard carton that holds a minimum of 6.5 kg of fruit. The recommended package for domestic markets is the AUF/8 single layer tray (485 to 490 mm x 325 to 330 mm external dimensions). Internal depths range from 90 to 135 mm, depending on fruit size. The cartons must be of sufficient strength to withstand transport, high humidity, stacking and movement in and out of cold rooms. They should also be vented to assist forced-air cooling of fruit.

Fruit is pattern packed, stem end down, into the tray. Plastic or fibreboard inserts with cups are used to help with fruit placement, and to pack fruit into a tight arrangement. The gross package weight is between 7 and 7.5 kg.

Fruit for export may be packed in smaller 5 kg cartons. Export fruit may also be packed with socks to help protect the fruit from damage during transport.

Fruit stickers

Individual fruit stickers are commonly used to brand fruit. These stickers usually have a Price Look Up (PLU) number or a bar code on them to help with commodity description at the retail level. The PLU numbers that apply to mangoes are in Table 9. An advantage of this system is that large supermarket chains can stock more than one size of fruit at different prices.

Table 9. *PLU numbers for mangoes*

Variety	Size (count)	PLU number
Kensington Pride (Bowen)	Extra Large (less than 12)	5298
Kensington Pride (Bowen)	Large (12 – 14)	5738
Kensington Pride (Bowen)	Medium (16 – 18)	5739
Kensington Pride (Bowen)	Small (20 and more)	5470
Glenn		5401
Green eating		4311
Haden		5402
Irwin		5403
Keitt	Large (12 – 16)	5404
Keitt	Medium (18 – 20)	5405
Keitt	Small (22 – 25)	5406
Kent		5407
Nam Doc Mai		5411
Organic		5392
Palmer		5412
R2E2	Extra Large (9 and less)	5741
R2E2	Large (10 and more)	5742

Package labelling

Correct labelling of produce is important. At least one end of the package must bear the name and address of the grower/packer in letters at least 5 mm high. Labelling must be typed or stencilled and not hand-written (Figure 23). The following items must be in letters at least 10 mm high:

- the word 'mangoes'
- the Class
- the size or count
- the variety or acceptable abbreviation
- package marking requirements for Interstate Certification Assurance (ICA).

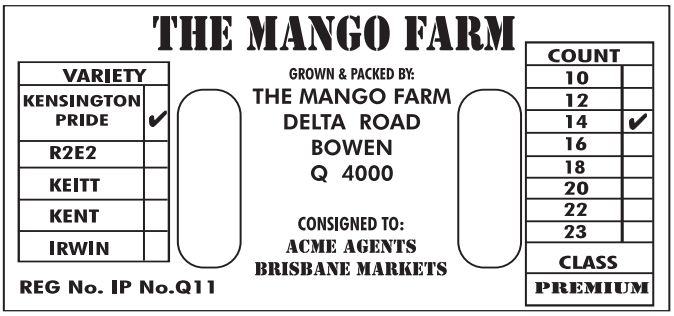


Figure 23. *End panel labelling for a tray of mangoes*

A batch code to identify when the mangoes were picked is recommended. This enables each package to be traced back to the orchard to help solve problems if they occur.

Palletising

For transport inside Australia the pallet used is the Australian standard pallet that measures 1165 mm x 1165 mm. This pallet holds 8 AUF/8 cartons per layer. Pallets are generally stacked 16 layers high with a total of 128 cartons per pallet. The cartons are supported with pallet corners, strapping and the top lids may be taped in place.

To improve strength the first five to ten layers are column stacked and then the rest are cross stacked, as shown in Figure 24, although the best stacking is obtained by full-column stacking.

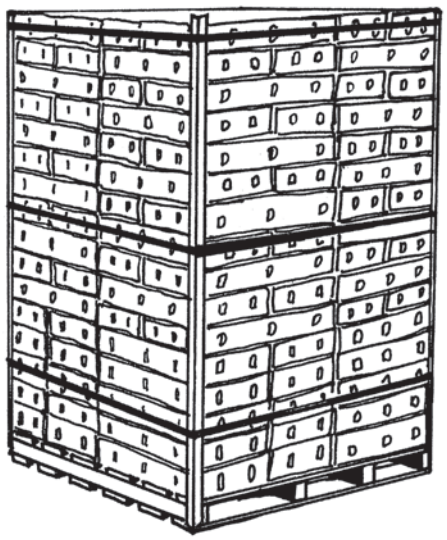


Figure 24. *Pallet stacking arrangements*

Final product check

The purpose of a final product check is to ensure you are meeting the grade standards you have set for your business. Check your fruit quality during the packing operation by following these five steps:

1. Randomly select a sample of each grade of each consignment.
2. Inspect about 2% (two trays out of every 100) of the packed trays.
3. Check this sample of fruit for all external aspects of quality. Record these objective assessments.
4. Keep a sample of fruit aside to ensure they ripen properly.
5. Ask your wholesale agent or retailer to provide feedback on the quality of your fruit.

Common packing problems

Incorrect sizing

Undersizing is the most common fault with packing. The insert cups are designed to aid packing, not to hold fruit in place during transport. Fruit movement is prevented by supporting fruit against each other. Packs with the correct fruit size hold at least 6.5 kg of fruit. Loose packs result from packing undersized fruit and have a poor appearance at the market. Tight, well-filled packs of similar sized fruit attract buyers.

Stem end visible

Fruit are best packed with the stem end down. The blush may be more noticeable on the stem end but skin blemishes such as sapburn and abrasion marks are more pronounced. The stem plus the skin blemishes have an unsightly appearance.

Poor quality fruit

Poor quality fruit cannot be hidden in tray packs. Care must be taken to pack only good quality fruit. Fruit with severe skin blemishes destroys the appearance of tray packs and is unattractive to buyers.

Temperature management

Temperature management plays a vital part in the ripening, storage and transport of mangoes. Fruit that is held at room temperatures will start to ripen soon after harvest. As ripe fruit is susceptible to bruising and damage during transport it is best to delay ripening so that fruit will not soften until it is at the final destination. Controlling the fruit temperature will give some control over the time to eating ripe. The conditions in which fruit is stored will also determine the quality, appearance and shelf life.

The best temperature management strategy will depend on the expected marketing period from harvest to consumer. You will need to know whether the fruit is to be sold immediately or whether it will be stored by the wholesale agent. Then use temperature management to give you some control over the marketing period and shelf life your

fruit consignment will achieve. There are three stages of postharvest life and each stage has different temperature tolerances.

Mature green. Green fruit can tolerate temperatures between 10° and 13°C. Holding fruit at these temperatures will delay the onset of ripening. Storing fruit below these temperatures leads to chilling injury. The lower the temperature and the longer the storage time, the more severe the injury symptoms will become. Green fruit can be held for up to two weeks before the ripening process starts. Keep an eye on the fruit at all times. If it starts to ripen it must be brought up to 20°C.

Ripening. As soon as the fruit begins to ripen the storage temperature must be maintained between 18° and 22°C. At temperatures below 18°C, skin colour development is slow and flavour development poor. At temperatures above 22°C, the flesh will soften but the skin colour will remain green or develop an unattractive green-yellow mottle. Postharvest diseases also develop more quickly at temperatures above 22°C.

Eating ripe. When the fruit is close to eating ripe the fruit will tolerate cooler storage temperatures again. The best storage temperatures are between 10 and 13°C but the fruit will tolerate a short period at lower temperatures. At this stage shelf life is limited but it can be extended for another three or four days by storing at 7° to 10°C. Do not store ripe mangoes below 5°C.

Always maintain a relative humidity between 85 and 95% while in storage.

Pre-cooling and transport

The first step in the cool chain is pre-cooling. Field heat should be removed from the fruit as soon as possible after harvest and the fruit kept cool from then on. However, simply placing pallets into a cool room does not achieve fast effective cooling throughout the pallet. Neither is refrigerated transport sufficient to bring fruit down to storage temperatures. Transport will only maintain fruit at the loading temperature in the upper rows.

If fruit arrive at the market above the optimum ripening temperature, there is a greater risk that fruit will prematurely ripen. The outcome will be green ripe fruit and reduced saleability.

High ripening temperatures have a compounding effect. Mangoes that are ripening produce heat, resulting in hotter fruit if they are not effectively cooled. The hotter the fruit, the more heat they produce. Fruit at 25°C produce twice as much heat as at 20°C.

Even when fruit arrive at the market at the optimum ripening temperature, ripening heat must be removed to maintain the optimum ripening conditions.

For effective cooling, mangoes must be placed into a cool room at 18°

to 22°C and the pallets either placed under a forced-air system or air stacked onto other pallets (Figure 25).

The temperature for pre-cooling and transport depends on whether the fruit is to be sold immediately or stored by the wholesale agent. For immediate sale, pre-cool and transport fruit at 18° to 20°C. If fruit is to be stored, a lower temperature of 10° to 13°C should be used.

To the consumer in less than 10 days

If fruit is to be sold in less than 10 days it should be pre-cooled and transported at 18° to 22°C. Ripening can be initiated at the farm or at the markets.

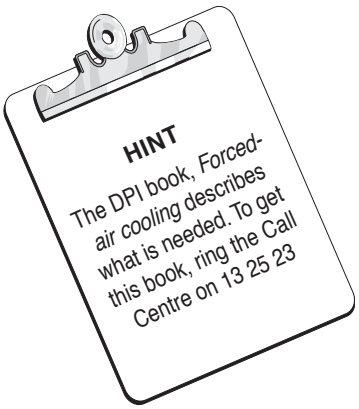
To the consumer in more than 10 days

If you need more than 10 days some storage or transport at lower temperatures is needed. This fruit must be carefully monitored. If there are any signs of the fruit beginning to ripen, it should be removed from cool storage and allowed to ripen at 18° to 22°C. When fruit are close to eating ripe they can be placed back into 7° to 10°C.

Forced-air cooling

Forced-air cooling involves forcing cold air through containers or past individual pieces of fruit to rapidly cool the fruit. A forced-air system can be set up inside existing cool rooms and can cool fruit to the correct ripening temperature within 12 hours.

A forced-air system uses a fan to create a chamber of low pressure on one side of the pallet that subsequently causes cold air to flow through the container from the high to the low pressure side. A blind or cover is normally used to ensure that the airflow is through all the packages and does not short circuit the system.



Two cooling techniques can be used:

Tunnel cooling. A row of pallets is placed either side of an air channel. The same number of pallets must be placed in each row. A blind is then run over the top and down the end of the air channel. Air is then pulled through the trays into the air channel and back through the auxiliary fan and cooling unit. This technique can use either a free-standing fan or a permanent wall mounted system to pull air through the pallets.

Single pallet cooling. The best design for cooling single pallets is the coldwall system. In this system the pallets are placed against openings of similar width in a plenum. Openings must be closed if not in use. Air is pulled through the containers into the plenum and back through the auxiliary fan to the cooling unit (Figure 25).

A technique for small operations where floor space is restricted involves placing an individual fan over the central chamber of each pallet, pulling air through trays into this central chamber. The bottom of the central chamber should be covered so air does not pass through the bottom of the pallet.

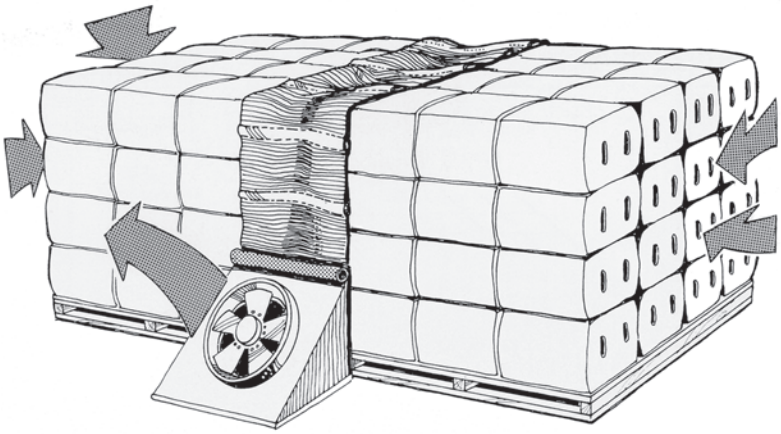


Figure 25. *Forced-air cooling system. A row of pallets is placed either side of an air channel; a blind is run over the top. Air is then pulled through the trays into the air channel back through the auxiliary fan and the cooling unit. (Photo courtsey* AUF Fresh Produce Manual*)*

Transport to market

Fruit is usually transported in refrigerated containers by road or rail. Air transport is too expensive for domestic fruit. Choose a reliable transport company. Ask about insurance arrangements and how they will ensure that the correct transport temperatures for your fruit are maintained.

Ripening fruit

Ripening fruit
Section 4 page 53

Most retail buyers want to purchase mangoes that are close to or at the ready-to-eat stage. Ripening can be triggered by surrounding the fruit with ethylene gas. Ethylene is a gas that is naturally produced by fruit when it ripens. Twenty-four hours surrounded by ethylene is enough to trigger the ripening process.

Some growers choose to ripen fruit on the farm while some agents prefer to ripen fruit at the market place. The decision on where to ripen fruit should be made in consultation with your wholesale agent.

After triggering you can expect fruit held at 18° to 22°C to start to yellow and soften in one to three days. They will then take a further four to six days to reach eating ripe.

Marketing

There are several ways of selling your fruit. Whatever market outlet you choose, always keep in close contact with your customer and ask for feedback on the quality of your fruit. This section discusses the different outlets and quarantine requirements for interstate sales.

Market outlets

Knowing what your customers want is the key to successful marketing. Don't expect your customers to tell you voluntarily—you need to ask them. They are often busy dealing with a range of crops and growers. Visit the major market in which your fruit is sold at least once a season. Be prepared to become involved in the promotional activities of local grower groups.

Wholesale agents

Fruit can be consigned to wholesale agents in the major metropolitan produce markets. Wholesale agents may sell fruit on your behalf and charge a commission on the sale price, or buy your fruit and then resell it to their customers.

more info
Grower associations
Section 6 pages 3, 4

Most Queensland mangoes are consigned to wholesalers in Brisbane, Sydney, Newcastle, Melbourne and Adelaide. Wholesalers are also a source of market intelligence. For this reason, your choice of wholesaler is extremely important. It is best to deal only with a wholesaler who understands mangoes. Seek advice on selecting your wholesaler from the Queensland Fruit & Vegetable Growers Association or the market authority in each market. Other growers in your area can also be a source of advice.

more info
Market information
Section 6 page 12

Marketing groups

When you join a marketing group, marketing decisions are made on a group basis. The major advantage is that the combined resources and the larger volume of product allow growers access to a greater range of marketing opportunities. Groups give individual growers more market share.

Direct sales to supermarkets and fruit barns

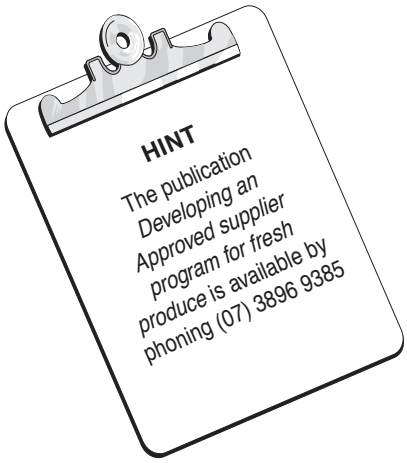
Supermarket chain stores and fruit barns in major cities will buy mangoes directly from growers. These outlets require a regular supply of uniform quality fruit. This marketing method is only suitable for very large orchards or marketing groups.

Local outlets

Growers can supply local district retailers, resorts and restaurants. You are involved in organising the sale and distribution of fruit, and though this can be hard work some growers find it rewarding.

On-farm or roadside sales

Some growers sell fruit on the farm or from a roadside stall. For this to be successful, you need to be near large towns or cities or have good passing traffic. You also need good road access so customers can easily get to the farm. Check on the requirements from your local authority and take out public liability insurance.



Selling 'on the tree'

The mango crop can be sold 'on the tree'. In most districts contractors will buy fruit 'on the tree' and resell the packed product.

Export

Growers can export mangoes, but specialised requirements must be met. Seek advice from export market consultants and the Australian Quarantine & Inspection Service (AQIS) before you decide to export mangoes. Most growers export through agents at the wholesale markets or sell through specialist exporters.

Processors

Fruit can be sold to processors. Fruit for processing still needs to be sound and of reasonable quality.

Market intelligence

Information on prices and throughput for all wholesale markets can be obtained from several sources. Queensland Fruit & Vegetable Growers also act as a representative body for horticultural growers. They provide a range of information relating to particular issues affecting the mango industry. Several consultants in the market place also provide market information as well as quality out turn reports and feedback on the condition of your fruit.

Daily market price and throughput information is available by phoning 1902 260 663.

more info
Market information
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Quality management
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Quality management

The demand for quality management systems at the farm and packhouse levels has grown significantly in recent years. The major catalyst has been the growing demand from consumers and retailers for safety standards for all food, including fruit. These standards include minimal chemical residues, lack of food contamination organisms, and freedom from foreign matter. This builds on top of demands for other quality parameters such as good shelf life, colour and flavour.

At present, all major retailers are putting in place systems where produce will only be bought from suppliers that can guarantee food safety standards based on a Hazard Analysis and Critical Control Point (HACCP) food safety and quality management system. Growers who wish to supply major retailers direct will have to implement one of those systems.

The practices included as part of the quality system will include the following:

- Product and handling specifications that outline how your mangoes will be delivered.
- Product identification and traceability that shows you can identify all of the treatments applied to a consignment of fruit from the paddock through packing.
- Staff training that shows the person responsible for chemical application is appropriately trained and that packing staff are trained in product specification and personal hygiene standards.
- Measures to control quality hazards that show you are aware of where quality could be compromised and that you have in place procedures to ensure that these hazards are minimised.
- Measures to control food safety hazards that show you only apply approved chemicals and observe withholding periods and prevent contamination of the fruit by objects such as wood or glass. You must show that you keep equipment clean and that staff handling the produce observe good hygiene. You will need to maintain records of your spray applications.
- Packing premises are constructed and maintained to prevent physical, chemical or microbial contamination of packages or produce at any time.

Markets and importing countries may soon demand assurances for best practises in all sections of the industry. This may include proof of sustainable environmental practices in the future. It is important that growers are ready for this change and start to develop a quality management system at the farm level now.

Interstate quarantine

Mangoes are susceptible to several pests that are quarantined by other states. The major pest is Queensland fruit fly but mango seed weevil and melon thrips also affect the free movement of fruit into some states. To send fruit interstate growers must comply with the documented requirements. A certification agreement has been developed for fruit fly that allows growers to certify that they have treated the fruit correctly without the need for continual inspections. On-farm inspections are still an option but at the grower's cost.

Interstate Certification Assurance (ICA)

ICA officers
Section 6 page 16

The DPI has instigated a system of standard procedures to meet the quarantine requirements of other states. These procedures cover the treatments required for control of fruit fly and other quarantine pests. They are audited and certified by Interstate Certification Assurance (ICA) officers. Growers should contact their nearest ICA officer for details of the procedures available for mangoes.

Table 10 lists the quarantine requirements for sending mangoes interstate.

Table 10. *Interstate requirements for exporting mangoes*

State	Requirements
New South Wales	There are no restrictions imposed on sending fruit to the Sydney and Newcastle markets. Growers consigning fruit to the Fruit Fly Exclusion Zone (FFEZ), formerly the Murrumbidgee Irrigation Area (MIA), will need approval from the senior inspector (regulatory), NSW Agriculture, Yanco, Ph: (02) 6951 2611.
Victoria and	Fruit can be sent under an ICA arrangement which uses a systems approach including preharvest treatment (cover sprays and bait sprays), postharvest inspection and postharvest treatment.
Western Australia	Mangoes from Queensland are prohibited due to mango seed weevil (MSW). Properties that can show that they are free of MSW, that all mango plantings within 1 km are also free and that no MSW infestation has been recorded within 50 km, may send fruit under a property freedom protocol. An inspector would have to sample fruit from your property and your neighbours' before harvest and at the market.
Tasmania	Fruit can be sent under an ICA arrangement or a DPI inspector can supervise treatment and packing of fruit and issue the necessary certificate. Tasmania requires that fruit is kept secure from the possibility of fruit fly infestation after packing. This may include shrinkwrapping and security taping pallets or sending fruit in security sealed containers. For growers south of Gympie and east of Toowoomba a DPI inspector will also need to certify their produce is free from melon thrips or obtain an area freedom from melon thrips certificate.
Northern Territory	There are no restrictions on sending mangoes to the Northern Territory.