

# Citrus information kit

Reprint – information current in 1997



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This publication has been reprinted as a digital book without any changes to the content published in 1997. We advise readers to take particular note of the areas most likely to be out-of-date and so requiring further research:

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- Financial information—costs and returns listed in this publication are out of date.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](http://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 1997. 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 citrus. This information is not to be used or relied upon by users for any purpose which may expose the user or any other person to loss or damage. Users should conduct their own inquiries and rely on their own independent professional advice.

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# Key ISSUES

*This section contains more detailed information on some of the important decision making areas and information needs for citrus. The information supplements our growing and marketing recipe in Section 3 and should be used in conjunction with it. The information provided on each issue is not designed to be a complete coverage of the issue but instead the key points that need to be known and understood. Where additional information may be useful, reference is made to other parts of the kit. Symbols on the left of the page will help you make these links.*

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## Understanding the citrus tree

*The aim of citrus growing is to produce a large crop of high quality fruit. To achieve this, it is essential to have a basic knowledge of the factors governing fruit production and quality. Here are the important things you need to know.*

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### **The annual cycle of the bearing citrus tree**

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#### **Vegetative growth**

The citrus tree is an evergreen tree, producing leaves which normally stay on the tree for one to two years. Leaves are continually replaced by new ones with the heaviest fall occurring during the spring. The tree produces three main leaf flushes (periods of new shoot growth) per year. The most important is generally the spring leaf flush which in Queensland occurs from July to October. Another leaf flush occurs in summer during December/January and a third in autumn during March/April. The flushes are less distinct and leaf growth more continuous in lemons and limes and in warmer subtropical and tropical areas. During winter, except in tropical areas, root and shoot growth slows to a minimum, although the trees do not become technically dormant.

#### **Flowering**

In most areas, trees flower once per year in the spring. The exceptions are: in the tropics where trees may flower continually; in lemons and limes where a number of flowerings generally occur; and in trees stressed by a lack of water. In the normal situation above, flowers are induced in early winter. Timing is influenced mainly by temperature, being earlier in warmer areas. The flowers are mainly produced in the leaf axils of shoots of the preceding spring flush. Flower emergence continues for four to six weeks.

More than 30% of the flowers drop off before full bloom. The remaining flowers may set but most will drop off during a period of natural fruit drop from mid November to late December. Only 1 to 4% of flowers go on to produce mature fruit.

The flowers of most citrus varieties are self-compatible (can be fertilised by their own pollen) and most set good crops without cross pollination from another variety. Some varieties may produce more and larger fruit from cross pollination but in practice, no significant effort is made to improve cross pollination, with most citrus grown in large single variety blocks. Although most varieties produce viable pollen, Navel oranges and Tahitian limes produce fruit without fertilisation (called parthenocarpic fruit). This means these varieties produce largely seedless fruit. Most others produce some seeds, the degree depending on the variety and its isolation from other citrus varieties. The Clementine mandarins, for example, produce seedless fruit if grown at least 500 metres from other citrus varieties.

### **Fruit development**

Fruit develop through three main growth stages:

- cell division where most of the cells of the fruit are formed (this occurs from bloom to about November),
- cell expansion which is the period of maximum growth of fruit size, increase in total soluble solids or sugars, decrease in acidity and the commencement of skin colour change (this occurs from about December to just before maturity),
- fruit maturation where the skin colour continues to change with a continuing increase in total soluble solids and decrease in acidity. (this occurs in the last few weeks before maturity).

Citrus fruit have no clearly identifiable point of absolute maturity. Colour can serve to help but this depends on the variety and the temperature. For oranges, mandarins and grapefruit, the most appropriate maturity indicator is the ratio of total soluble solids to acidity. For lemons, the most appropriate maturity indicator is juice percentage.

Temperature plays an important role in fruit development and fruit quality. Cool night temperatures near harvest produce richer skin colour. A reasonable day/night temperature fluctuation improves flavour. Total heat accumulation determines sweetness and time taken for fruit to ripen.

### **Implications for crop management**

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Experience has shown that high performing trees follow a particular pattern of leaf growth, flowering and fruit development leading to a large crop of high quality fruit. The aim of crop management is to keep trees within this desired cycle by carefully managing fertilising, watering and other operations.

#### **Young, non-bearing trees**

During the first three or four years, the aim is to grow a strong, healthy canopy of branches and leaves as quickly as possible. This involves a



Citrus nurseries  
Section 6 page 5



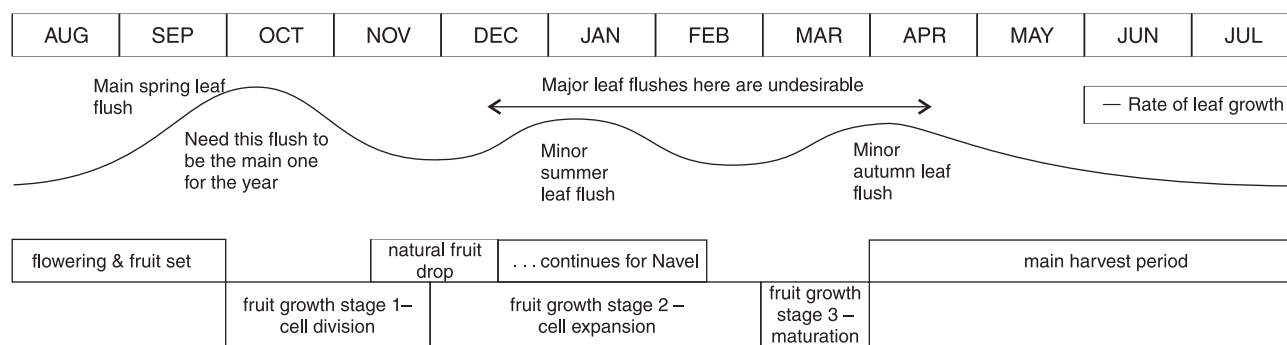
How to plant trees  
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number of key management steps:

- Purchase healthy trees from a specialist citrus nursery. Pre-arrange where possible to receive trees at an appropriate stage of root development. Old, pot-bound trees have thick, matted roots which often poorly colonise the surrounding soil when planted out. When trees are received, check that the scion and rootstock are as ordered. Then check that the trees have good leaf colour, are free from pests and diseases and have been hardened to full sunlight.
- Ensure the trees get the best start by carefully preparing the planting site and using good planting technique.
- Provide optimum conditions for tree growth by supplying adequate fertiliser and water, controlling weeds, diseases and pests such as leafminer, mulching to create a better root environment, and minimising wind and frost damage.
- Minimise the time taken to reach bearing size by limiting pruning to the correction of tree structural problems only.

### Bearing trees

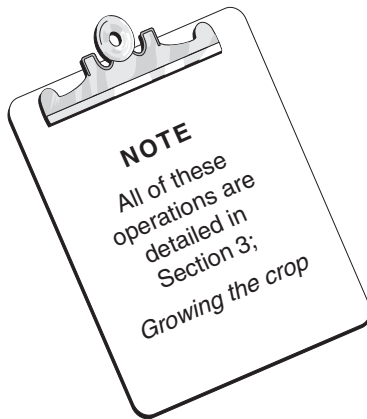
Once trees begin to bear, the focus of management changes. The aim from the fourth to the eighth year is to increase the fruit bearing surface rapidly while at the same time producing quality fruit. By the eighth year when trees should have filled in most of the area available, the sole aim is the maximum production of quality fruit. The desired annual cycle for trees at this stage is shown in Figure 1. Note that in high density plantings, early and heavy cropping in Imperial mandarins is an advantage as it reduces vegetative vigour and helps to delay the time for tree removal.



**Figure 1.** Desired annual cycle for bearing trees (timing is for Navel orange)

Keeping trees within this desired cycle to produce quality fruit involves a number of key management operations:

- Manage fertiliser, particularly nitrogen fertiliser, to produce a very strong spring flush and small summer and autumn flushes. The strong spring flush sets up the fruiting wood for the next crop and the small summer and autumn flushes avoid competition for nutrients with the developing and maturing fruit. This means applying all or most of the nitrogen fertiliser just before the spring



flush (except for Murcott which benefits from periodic light applications from June to March). It also means monitoring nutrients in the leaf tissue and soil to ensure all other nutrients are maintained in their optimum ranges.

- Ensure that water supply is adequate particularly during the critical period in spring when a combination of the spring leaf flush and developing fruit places great demand on available moisture. This requires the use of soil moisture monitoring devices to carefully schedule irrigation to the needs of the tree. It also means controlling weeds within the root zone to remove competition for water and nutrients.
- Prevent damage to the main leaf flushes and fruit by controlling pests and diseases and minimising wind and frost damage.
- Maximise the production of sugar and starch in the tree by ensuring as much of the leaf canopy as possible is available for photosynthesis. This requires regular pruning to ensure adequate penetration of light into the canopy. Pruning also reduces fruit marking, allows for easier harvesting and ensures more effective spray penetration for pest and disease control.
- Thin fruit, particularly in mandarins, to avoid overcropping, reduced growth and alternate bearing, which throws the tree out of the desired cycle.



## Economics of citrus production

*New growers are being attracted to citrus by the perception of good returns from buoyant prices on the domestic market. This is particularly so for mandarins. Bigger investors also see excellent export potential, particularly in Asia. However, price is only one factor in the equation and a sensible appraisal of the prospects for citrus is only possible with a thorough economic analysis. This section provides some perspectives on the profitability of citrus growing.*

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### Background to the analyses

Two different but related economic analyses for citrus are summarised in this section. The first is a large study in the Central Burnett region which compares three typical mixed variety orchards of 7, 18 and 50 hectares of mature trees. The second is a study from the Mareeba-Dimbulah irrigation area which analyses a model or hypothetical farm of 10 hectares of Murcott mandarins.

Both studies produce annual whole orchard profit and loss statements at orchard maturity. These include gross income, variable costs and fixed costs on a whole orchard basis. The variable or operating costs include the growing, harvesting and marketing costs. The fixed or overhead costs include an allowance for permanent labour and the farmer's own labour, administration costs, electricity, and depreciation. A gross margin, which is the difference between the gross income and the variable or operating costs, is calculated.

The second study includes a discounted cash flow analysis to determine the annual cost of production and profitability. It is a technique used widely to analyse profitability for long term tree crops where costs and benefits occur over a long period of time. The technique reduces the time stream of costs and benefits to an equivalent amount of today's dollars. That amount is known as the present value of the future stream of costs and benefits. The present values are calculated using compound interest and a specified discount rate (in this case 6%). The Net Present Value (NPV) is the difference between the present value of the benefits and the present value of the costs.

## Economics of citrus growing—Central Burnett

### Assumptions

The main assumptions made in the analysis are:

- The orchard consists of a mixture of oranges (three varieties), mandarins (seven varieties), lemons and grapefruit. However, two varieties of mandarins (Imperial and Murcott) make up 70% of the orchard with Navel oranges a further 17%.
- Trees are planted at standard densities with 7.3 metres between rows and 3.5 to 5.5 metres between trees.
- The orchard is considered to be at a 'steady state' where the replacement rate of trees throughout the various age brackets is constant. Trees are replaced at ages varying from 20 to 35 years.
- Mature tree yields are considered to be a district average of approximately eight cartons per tree.
- Prices are based on a seven year market average and are net of agent's commission. They are approximately \$23-24 per carton for Murcott mandarins; \$11-13 for Navel oranges, Ellendale and Hickson mandarins; \$9-10 for lemons and grapefruit; \$7-8 for Valencia oranges and \$10 per half-carton for Imperial mandarins.
- The orchard is well managed.

The profit and loss statement for the three orchard sizes is summarised in Table 1.

**Table 1.** Whole orchard profit and loss statement (at steady state)

Item	7 hectares		18 hectares		50 hectares	
	Total	per carton	Total	per carton	Total	per carton
No. of trees	2 360		6 163		15 450	
No. of cartons	16 248		42 489		108 875	
<b>GROSS INCOME</b>	<b>274 521</b>	<b>16.90</b>	<b>722 878</b>	<b>17.01</b>	<b>1 717 582</b>	<b>15.78</b>
<b>Variable costs</b>						
Fertiliser	4 157	0.26	10 686	0.25	29 577	0.27
Weed control	2 137	0.13	5 492	0.13	15 251	0.14
Insect/disease control	10 917	0.67	28 082	0.66	77 324	0.16
Irrigation	1 984	0.12	5 983	0.14	17 031	0.16
Pruning/thinning	2 230	0.14	5 656	0.13	14 795	0.14
Int. on working capital	2 571	0.16	6 708	0.16	18 510	0.17
Harvesting	223 525	1.45	62 474	1.47	154 999	1.42
Marketing	81 444	5.01	213 547	5.03	528 532	4.85
<b>TOTAL VARIABLE COSTS</b>	<b>128 965</b>	<b>7.98</b>	<b>338 628</b>	<b>7.97</b>	<b>856 289</b>	<b>7.86</b>



Item	Total	per carton	Total	per carton	Total	per carton
<b>Fixed costs</b>						
Permanent labour	25 000	1.54	80 000	1.88	201 660	1.85
Allowance—farmer labour	30 000	1.85	35 000	0.82	40 000	0.37
Administration	9 500	0.58	19 000	0.45	42 000	0.39
Repairs	20 000	1.23	40 000	0.94	60 000	0.55
Depreciation	32 492	2.00	66 609	1.57	148 475	1.36
Int. on fixed capital	19 350	1.19	41 441	0.98	93 670	0.86
<b>TOTAL FIXED COSTS</b>	<b>136 343</b>	<b>8.39</b>	<b>282 050</b>	<b>6.64</b>	<b>585 805</b>	<b>5.38</b>
<b>TOTAL COSTS</b>	<b>265 308</b>	<b>16.33</b>	<b>620 677</b>	<b>14.61</b>	<b>1 442 094</b>	<b>13.28</b>
<b>Return to management</b>	<b>9 213</b>	<b>0.57</b>	<b>102 200</b>	<b>2.41</b>	<b>275 488</b>	<b>2.53</b>
<b>GROSS MARGIN</b>	<b>145 556</b>		<b>384 250</b>		<b>861 293</b>	
<b>GROSS MARGIN/hectare</b>	<b>20 770</b>		<b>21 340</b>		<b>17 224</b>	
<b>GROSS MARGIN/carton</b>		<b>8.96</b>		<b>9.04</b>		<b>7.91</b>

A sensitivity analysis is contained in Table 2.

**Table 2.** Price sensitivity analysis

Prices	Return to management (\$ per year)		
	7 hectares	18 hectares	50 hectares
Standard prices	9 213	102 200	275 488
-5%	-3 700	67 951	191 759
-10%		33 702	108 029
-15%		-548	24 300
-20%			-55 429
-25%			
<b>Approx breakeven</b>	<b>-3.5%</b>	<b>-15%</b>	<b>-16.5%</b>

A broad list of the capital requirements for an 18 hectare orchard are listed in Table 3. An 18 hectare orchard is considered a viable unit for a family where citrus is the sole source of income.

**Table 3.** Capital requirements for an 18 hectare orchard

Item	Approximate cost (new)
Land	22.5 ha to allow for 18 ha of orchard and room for replants—costed at \$5000 per ha
	115 000
Machinery	Tractors x 2
	90 000
	Old tractors x 4
	20 000
	Fencing
	15 000
	Undertree irrigation
	85 000
	Slasher x 2
	12 000
	Bin trailers x 10
	5 000
	Herbicide sprayer
	5 000
	Small airblast sprayer
	13 000
	Oscillating boom sprayer
	30 000
	Utilities x 2
	26 000
	Truck
	30 000
	Tank & pump for truck
	10 000
	Fork lift
	20 000
	Ladders x 25
	10 000
	Bins x 150
	22 500

Machinery shed	40 000
Packing shed	200 000
Chemicals shed	10 000
Grading & packing equipment	150 000
Dipping equipment	3 000
Workers accommodation	20 000
Generator	9 000
Cool room/degreening room	15 000
Mulcher	7 500
Cherry pickers x 2	20 000
Cultivation & fertilising equipment	20 000
Tree establishment costs	23 904
Trees (6160)	49 280
Windbreaks	5 000
Motor cycle	3 000
Tools	7 000
Workshop	10 000
Office	15 000
Pruning gear	5 000
Picking bags	1 000
Carry-all	3 000
Miscellaneous	20 000

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<b>TOTAL</b>	<b>1 161 184</b>
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**Reference for further reading and research:** *The economics of growing citrus in the Central Burnett region of Queensland* by J.R. Peter Hardman (1994), Department of Primary Industries, Brisbane. (Information Series QI88015).

## **Economics of mandarin growing—Mareeba**

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### **Assumptions**

The main assumptions made in the analysis are:

- The orchard consists of 10 hectares of Murcott mandarins.
- Trees are planted at a standard density with 7.3 metres between rows and 3.56 metres between trees.
- Mature tree yields are considered to be approximately nine cartons (170 kg) per tree.
- Fruit was assumed to enter the Sydney market and export markets during early July when prices are high. A price of \$1.67/kg or \$30/18 kg carton is assumed.
- The orchard is well managed.
- The orchard has a life of 35 years and a discount rate of 6% is used to calculate the net present value (NPV).

The profit and loss statement for the 10 hectare hypothetical orchard is summarised in Table 4.

**Table 4.** Whole orchard profit and loss statement

<b>Item</b>	<b>Total</b>	<b>per carton</b>
No of trees	3 840	
No of cartons	36 270	
<b>GROSS INCOME (NPV)</b>	<b>509 022</b>	<b>30.00</b>
<b>Variable costs (expressed at NPV)</b>		
Fertiliser	6 466	0.36
Weed control	2 974	0.18
Insect/disease control	33 884	1.98
Irrigation	3 710	0.18
Pruning/thinning	3 158	0.18
Harvesting & marketing	222 782	13.14
<b>TOTAL VARIABLE COSTS (NPV)</b>	<b>272 974</b>	<b>16.02</b>
<b>Fixed costs (expressed at NPV)</b>		
Permanent labour	25 000	1.44
Allowance - farmer labour	25 862	1.44
Administration	10 000	0.54
Repairs & maintenance	12 229	0.72
Depreciation	31 949	1.80
Electricity	1 000	0.02
Fuel & oil	1 800	0.18
<b>TOTAL FIXED COSTS (NPV)</b>	<b>107 841</b>	<b>6.30</b>
<b>TOTAL COSTS (NPV)</b>	<b>380 815</b>	<b>22.50</b>
<b>Return to management</b>	<b>128 206</b>	<b>7.56</b>
<b>GROSS MARGIN (NPV)</b>	<b>236 048</b>	<b>13.98</b>
<b>GROSS MARGIN/hectare (NPV)</b>	<b>23 605</b>	
<b>GROSS MARGIN/carton (NPV)</b>		<b>13.98</b>

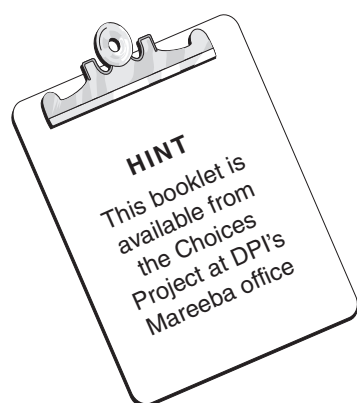
An analysis of discounted cash flow for the 10 hectare hypothetical orchard is shown in Table 5.

**Table 5.** Discounted cash flow analysis

Year	Yield (kg/yr)	Receipts	Operating costs	Fixed costs	Capital costs	Annual cash flow	Accumulated cash flow
0	0	0	0	12 500	264 001	-276 501	-276 501
1	690	1 150	6 942	75 029	0	-76 247	-352 747
2	3 450	5 751	11 772	75 029	0	-72 135	-424 882
3	69 696	116 161	62 511	75 029	0	-17 951	-442 833
4	113 860	189 767	101 055	75 029	0	10 839	-431 994
5	119 838	319 729	180 348	75 029	46 200	13 565	-418 430
6	218 750	364 584	207 734	75 029	0	57 680	-360 750
7	262 914	438 190	246 797	75 029	0	77 389	-283 361
8	342 962	571 603	315 253	75 029	0	113 763	-169 598
9	310 529	517 548	288 269	75 029	0	91 300	-78 298
10	311 909	519 848	289 274	75 029	124 847	17 141	-61 157
11	447 161	745 268	392 965	75 029	0	146 065	84 908
12	314 669	524 448	296 319	75 029	0	76 086	160 994
13	418 868	698 114	372 327	75 029	0	117 565	278 559
14	414 038	690 063	368 803	75 029	0	108 908	387 467
15	603 115	1 005 192	506 725	75 029	84 535	141 413	528 880
16	376 775	627 958	341 622	75 029	0	83 180	612 060
17	588 624	981 040	496 154	75 029	0	152 206	764 266
18	368 494	614 156	335 581	75 029	0	71 311	835 578
19	439 570	732 617	387 428	75 029	0	89 292	924 869
20	652 800	1 088 000	542 967	75 029	130 347	105 907	1 030 776
25	480 974	801 624	417 630	75 029	37 235	63 313	1 446 888
30	414 038	690 063	368 803	75 029	124 847	21 134	1 666 821
35	414 038	690 063	368 803	75 029	87 300	43 394	1 858 768
<b>Total (PV)</b>	<b>4 427 953</b>	<b>7 379 922</b>	<b>3 957 649</b>	<b>1 100 296</b>	<b>463 209</b>		

The analysis shows that the peak overdraft, \$442 833, occurs in the third year and annual expenses exceed annual income until the fourth year. The payback period, or the time required for accumulated income to exceed accumulated expenses, is 11 years. Put another way, this is the time required to recover the initial project outlay.

**Reference for further reading and research:** *Growing mandarins in the Mareeba-Dimbulah Irrigation Area—an economic perspective* by Andrew Hinton, in *Mandarins—Choices Seminar Series No. 6* (1994), Department of Primary Industries, Mareeba.





## Planning orchard layout

*Planning the layout of the orchard is often done hastily and without due regard for the long term consequences. Yet it is probably one of the most important steps in ensuring long term profitability and stability of the citrus orchard. This is because of the impact of orchard layout on land degradation and its subsequent effects on tree health, soil fertility and ease of access. It is all the more important because mistakes made at the orchard establishment stage are difficult and costly, if not impossible, to correct. Because orchard planning can be a complex procedure, it is recommended that you get some expert assistance. This is available free of charge from land conservation extension officers of the Department of Natural Resources. Here are the important things you need to know.*

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### **Understanding land degradation**

Land degradation is a term which is used to describe a permanent decline in productivity of land. Some forms of land degradation include soil erosion, soil structural decline, reduced fertility and increasing acidity.

The two most visible types of land degradation associated with horticulture in Queensland are gully erosion and mass movement including landslip.

These can occur individually or in combination with other less visible types, seriously threatening the long term viability of farms. Although these types of land degradation are most visible, they are not necessarily the most significant forms. Remember that by the time you see a gully, serious soil erosion and other problems already exist in the surrounding areas.

### **Gully erosion**

Soil erosion begins on bare or cultivated ground when raindrops seal the surface and dislodge soil particles which gradually move downhill. Any water flowing over the surface will carry this loose soil material with it, forming rills and eventually gullies. Where the soil surface is

bare and the topography steep, soil erosion losses can be dramatic. In extreme cases, more than 300 tonnes of soil can be lost from each hectare each year.

Sloping land should be treated with soil conservation structures such as diversion drains, v-drains and grassed interrow strips, to control soil loss before it becomes a problem. Water needs to be diverted away from crop areas at regular intervals to reduce the concentration and erosive potential of runoff.

### **Mass movement including landslip**

Landslips usually occur when an impervious layer of either rock or clay is present beneath the surface. When the soil is saturated and sub-surface water is flowing on top of the impervious layer, the ground can become mobile and move downhill. These movements are often sudden and can extend over several hectares, although most are quite localised covering only a few square metres.

Steep slopes, high rainfall and a lack of deep-rooted vegetation greatly increase the risk of landslips occurring.

Where landslips occur a range of rehabilitation measures can be used to make the slip and adjacent areas safe and stable. These include:

- locating diversion banks or drains above the slip area where possible, to intercept and divert runoff water away from the slip and into more stable areas
- re-shaping, when ponding occurs at the back of the slip, to remove water from this vulnerable area
- using agricultural drainage pipes to intercept and remove sub-surface water flows
- maintaining a good grass cover and using trees wherever possible to stabilise and 'dry-out' the slip area.

### **Off-site effects of land degradation**

The off-site or downstream effects of land degradation are costs borne not just by the landholder at the erosion source, but by the whole community. Transported soil material contains both fertilisers and chemicals which can have serious environmental consequences some distance from the soil erosion source. Land degradation caused by erosion within any catchment can lead to:

- sedimentation of culverts, drainage lines and watercourses which increases flooding risks and drainage costs
- deterioration of water quality
- reduced water storage capacity of dams
- pollution of dams, creeks and rivers by soil, agricultural chemicals and fertilisers.

## **The elements of good orchard planning**

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### **1. The best site**

Careful orchard site selection plays a big part in reducing the potential for land degradation. Here are the important points to consider.

#### ***Soil type***

Soil type has a major effect on the amount of soil loss. For example, sandy surface soils are generally more erosion-prone than clay soils. Of equal importance is the physical condition of the topsoil—called soil tilth. Soil which has been cultivated to a fine tilth when preparing planting sites is more susceptible to erosion damage than an undisturbed soil. Soils least likely to erode are those which are cultivated as little as possible and protected by a mulch or standing cover crop.

Problem soils are:

- heavy clays because they restrict root development and favour root diseases
- rocky soils because they damage implements and machinery
- light sandy soils because they have low water holding capacity and poor retention of nutrients
- poorly drained and shallow soils because they restrict crop growth and may cause tree death
- soils with unstable subsoil because they restrict root penetration.

The best soils for citrus are free-draining soils with no heavy clay or rock within at least one metre of the surface.

#### ***Aspect***

Slopes facing north, north-east and north-west are preferred, particularly in central and southern Queensland, as these are generally warmer and better protected from the damaging winds from the south-east in summer and the west in winter.

#### ***Slope***

Always select the flattest areas available. However, all sloping land will require some erosion control measures.

Slopes of up to 15% are preferred for safe machinery operation and allow a wider range of options for farm layout and soil erosion control. They also enable easier provision of all-weather access to the crop, which is vital for harvesting and pest and disease control.

Slopes or more than 15% make it difficult to operate machinery safely and carry a high risk of erosion damage. Remember that erosion removes valuable topsoil and nutrients reducing tree vigour and productivity. Steep slopes can also lead to erosion of access tracks

resulting in post-harvest fruit damage during transport. Consequently, steep slopes require more substantial and costly erosion control measures.

### **Wind protection**

As mentioned earlier, protection from damaging south-easterly and westerly winds is essential. Wind can severely damage trees through limb breakage as well as reducing yields and fruit quality. It also increases evaporation thereby making irrigation less efficient, and may cause wind erosion. Unprotected orchards also have less flexibility in spray application and sprays are more subject to drift. Wind protection can be offered by natural stands of timber but planting of windbreaks is recommended on all farms.

### **Access to irrigation water**

Check that you have access to sufficient quantities of good quality irrigation water. As a rule of thumb, two years supply is regarded as the minimum level for maintaining a crop throughout periods of drought.

## **2. A planning map**

Prepare a map of the farm on which you can develop a plan for windbreaks, on-farm access, erosion control structures, water harvesting and storage, and the irrigation system. To avoid costly mistakes, seek professional advice.

## **3. Good windbreaks**

There are four options for windbreaks:

- retain existing natural stands of timber
- plant tall, quick growing grasses such as bana grass. When planted in spring, it will form a dense windbreak by the next winter. Annual maintenance by deep ripping close to the grass to sever roots is required to prevent it spreading into the root zone of the orchard trees.
- plant dense, quick growing trees and shrubs. Two or more rows of trees and shrubs provide the best protection.
- erect artificial windbreaks. These are commonly constructed of mesh materials such as shadecloth but are expensive.

Retaining natural timber and planting trees and shrubs to supplement the natural timber is the best option. So before clearing, seek professional advice on the way you go about your clearing. Leave windbreaks on all sides of the intended orchard site where possible. Leave timber on all major drainage lines as these can be used to safely dispose of runoff water from the crop. If planting windbreak trees, make sure they are at least 10 metres from the citrus trees to allow machinery access and to reduce shading and root competition.



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#### 4. All-weather on-farm access

All-weather access is vital for the efficient management of an orchard. This provides for unhindered machinery movement for harvesting, spraying and other field operations. Major access tracks can be easily maintained if the water from adjoining fields is shed away from the track (see Figure 1). Tracks should be constructed four metres wide. This allows for the movement of spray equipment and harvesting trailers without damaging the trees.

Important points to remember are:

- Locate access tracks on ridgelines wherever possible.
- Plant the trees parallel to access tracks on ridgelines where slope permits.
- Always shed runoff away from access tracks.
- Use contour drains to move this water to stable watercourses/gullies.
- Concrete pipes will often be needed when crossing major drainage lines. Concrete or rock inverts are ideal for dam spillways and other regular crossing points.
- Ensure access tracks are constructed and maintained at least four metres wide.
- Most access tracks require 'whoa boys' or speed bumps to catch and divert water safely off the track. In most situations, these should be no more than 50 metres apart and are best located where slope changes or suitable outlet points are found.

#### 5. Erosion control measures

Uncontrolled water runoff causes the loss of valuable topsoil and exposes the surface roots to desiccation. It may also pool within the orchard causing waterlogging and root rot. Surface drainage structures such as contour drains and v-drains are required to safely dispose of runoff into stable waterways. These structures are designed to shorten slope lengths to reduce the impact of erosion and to prevent ponding around the roots. It is essential that these structures are correctly designed, implemented and maintained. Failure of structures will result in increased levels of soil erosion. For this reason, seek expert assistance in designing them.

Here is an overall view of what's required:

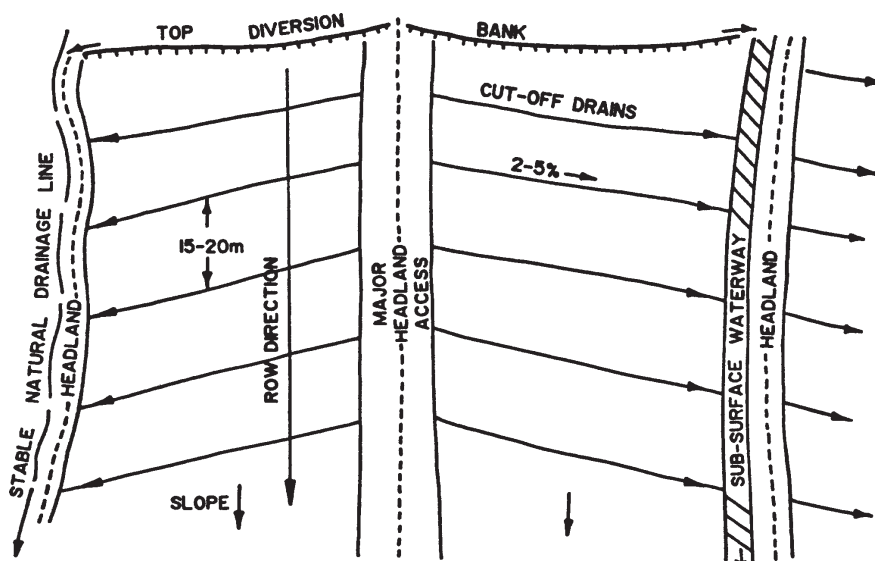
- On slopes of up to 4%, rows can be run across the slope or up and down the slope without any soil erosion structures within the orchard.
- On slopes of 4 to 15%, rows can be run across the slope or up and down the slope but contour drains or v-drains are required within the orchard to control runoff. If rows are run across the slope, locate drains and rows as close as possible to the contour with a fall of 2



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to 5% to safely remove water (Figure 1). If rows are run up and down the slope, contour drains are required at least every 50 metres down the slope. A slope of 15% is the safe maximum limit for working a two wheel drive tractor across the slope.

- Slopes greater than 15% generally should be avoided, but if they are planted, run rows up and down the slope for safe machinery use. Cut-off drains will be required at regular intervals down the slope to intercept runoff water (Figure 1).



**Figure 1.** General layout for crops on steeper slopes

- The orchard needs to be protected from water flowing from land directly above it by building a diversion or contour drain at the top of the site (see Figure 1).
- On flatter ground, row direction should suit the design needs of the irrigation system. Consult a qualified irrigation designer for assistance with this.
- Try to get long rows as these are preferred for machinery efficiency but remember you need breaks in the rows to facilitate efficient harvesting.
- Do not use depressions or low points in the paddock as these carry runoff during storms. Maintain or replant these areas with a low growing, vigorous grass such as carpet grass, couch or African star grass. The grass must be regularly slashed to assist the rapid removal of runoff from the orchard.

### **Diversion drain**

A diversion or contour drain is required to protect sloping orchard land as water flowing from above will greatly increase potential crop damage and complicate water disposal problems as it concentrates further down the slope. The drain should be at a gradient of 1 to 5% and large enough to handle the water from the catchment above. The drain

should empty into a grassed waterway or a stable natural watercourse. Keep the steeper sections furthest from the waterway or watercourse. Table 1 contains information on maximum gradients for drains of different lengths on a range of different soil types.

**Table 1.** *Diversion drains: maximum gradients and lengths for different soil types.*

Diversion drain length (m)	Maximum gradients		
	Gravelly soils	Sandy soils	Red clay soils
50	3%	3%	5%
75	3%	2%	4%
100	2%	2%	3%
150	1 – 2%	1%	2%

To avoid overtopping or failure of diversion drains, they should be located using a levelling device, for example, a dumpy level, hand level, or water tube level. To prevent scouring of the drain channel, establish a creeping or sward-type grass such as carpet grass, couch or African star grass in the channel.

Contour drains within the orchard are built to similar specifications as diversion drains.

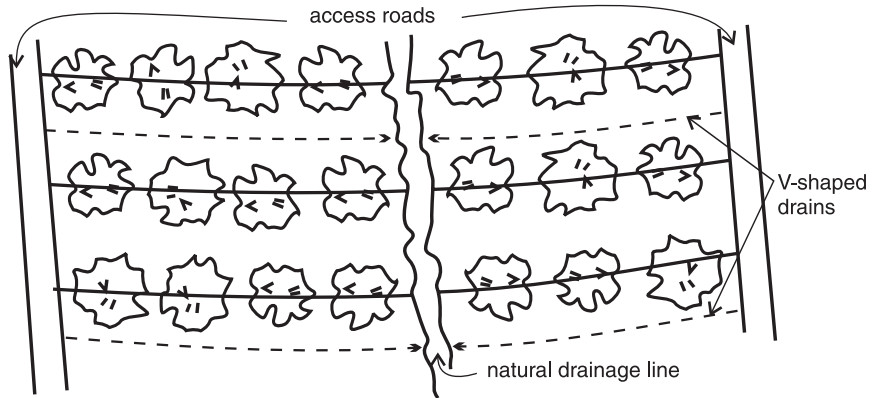
### **Waterways**

Diversion drains and all other runoff control structures should empty into stable grassed waterways—either natural depressions or constructed waterways. Constructed waterway channels are built below the ground surface level to allow rows and drains to discharge into the channel. They need a flat bottom channel, stabilised with carpet grass, couch or African star grass as above, to safely carry runoff water down the slope.

### **V-drains**

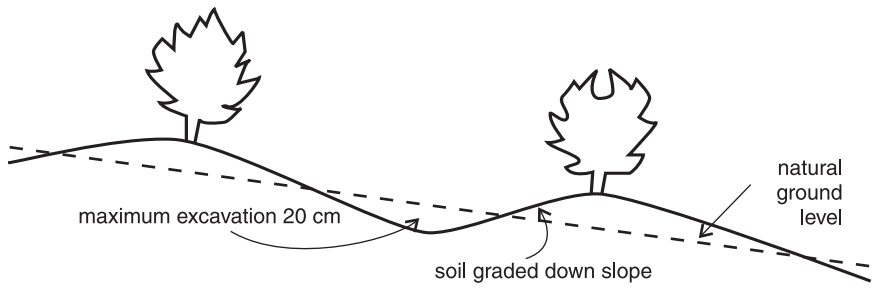
Within the orchard, shallow, wide v-shaped drains are constructed in the centre of the interrow to provide drainage and to control waterflow. Maximum excavation depth is 20 cm. They are usually built by a grader or tractor-mounted blade.

For rows across the slope, v-shaped drains are constructed every second or third row and angled across the slope at a 2% gradient. See Figure 2. The maximum distance between the v-drains should be 15 metres.



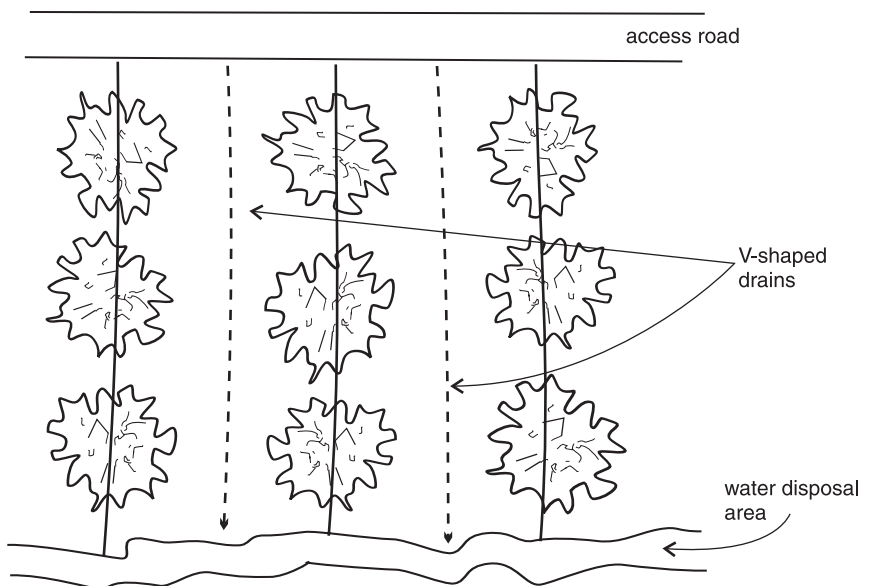
**Figure 2.** Across slope rows with v-drains (plan view)

Soil from the drain is moved onto the proposed downhill tree line. See Figure 3.



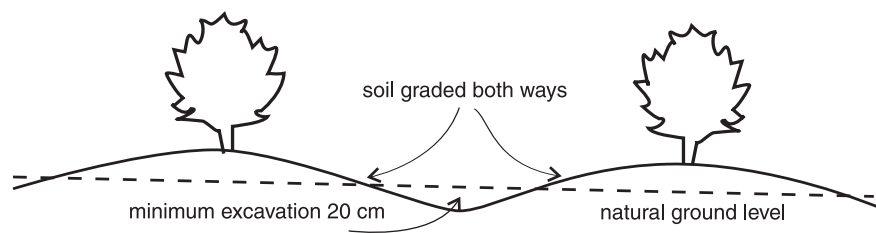
**Figure 3.** Across-slope rows with v-drains (cross-section view)

For rows up and down the slope, v-shaped drains are constructed between every interrow area to control side slope runoff. See Figure 4.



**Figure 4.** Down-slope rows with v-drains (plan view)

Soil from the drain is moved both ways on to the proposed tree lines. See Figure 5.



**Figure 5.** Down-slope rows with v-drains (cross-section view)

### **Bench terracing**

The construction of a series of bench terraces across the slope is suitable for specific locations. Because bench terracing involves major earthworks which are very expensive to construct, reshape or remove, they are recommended for use only in special circumstances and then only with expert assistance in their design and construction. A deep (stable) non-dispersible soil is essential for success with bench terraces.



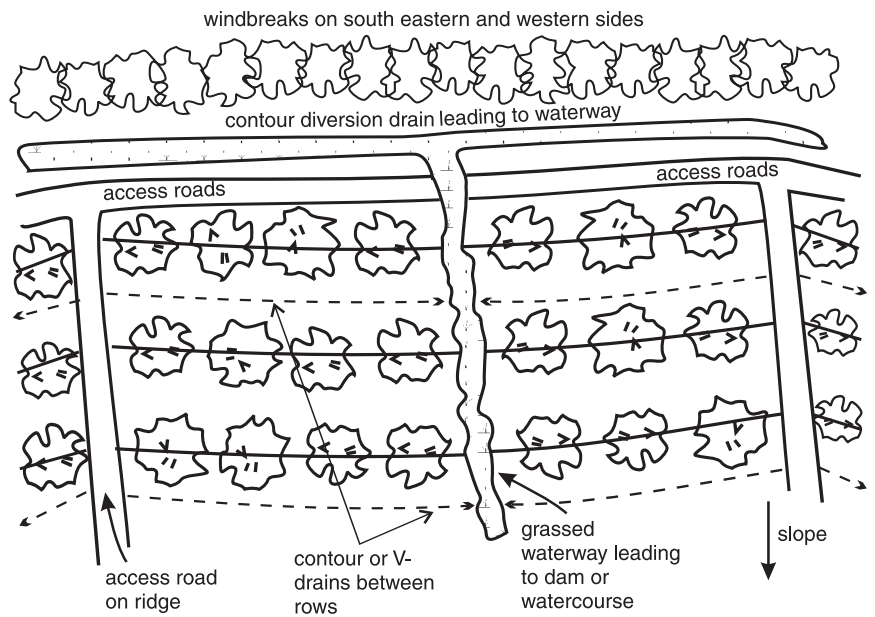
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## **6. Water harvesting and storage**

A good farm layout should incorporate water harvesting. This means that runoff is removed from the orchard site and directed into a dam for later irrigation use.

The type of irrigation system used should be integrated in the farm layout to be compatible with erosion control structures, access roads and drainage. For example, locate irrigation mains and hydrants close to access tracks. Undertree minisprinklers are preferred because of their lower water consumption and better water distribution. When planning irrigation, seek specialist advice from a qualified irrigation designer.

An example of an orchard design plan incorporating some of these features is shown in Figure 6.



**Figure 6.** An example of an orchard design plan

## The bigger picture

Following these planning principles will provide benefits to you and your farm as well as your whole catchment and community.

Joint Government and community initiatives encourage people to cooperate and work together on a catchment basis to reduce the offsite effects of land degradation. Adoption of the recommended planning principles will lead to a reduction in the impact of community problems such as:

- poor water quality due to nutrients contained in runoff water
- siltation of rivers, streams and harbours
- algae blooms in water storage
- loss of production caused by soil erosion.

For further information on how you can be more involved at a community level, contact Landcare and Catchment Management groups in the area in which you live.



## Selecting varieties

Success in commercial citrus production depends to a large extent on the correct selection of varieties. It is not always easy as there are not only many varieties to choose from, but also many differing opinions on which varieties are best. This section will help you make an informed decision about selecting varieties.

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### The basis for selecting varieties

Selecting varieties involves consideration of a number of factors:

- **the general acceptance of the variety in the marketplace.** In general, consumers are looking for brightly coloured, juicy fruit of reasonable size, with smooth, thin skins. Additional features sought in mandarins and oranges are sweetness and ease of peeling. There is an increasing demand for seedless varieties but at this stage it is not a significant factor in consumer purchase. In addition, varieties that have a well established reputation with consumers are generally better accepted than new unknown varieties.
- **the markets you are targeting.** Some varieties are more suited to the domestic market, some to the export market and some are dual purpose. Choice will depend on where you intend to specialise. Remember that all markets, but particularly export markets, require fruit of high quality with good shelf life. For this reason, there is little point in growing varieties targeted at the export market in areas where it is difficult to achieve fruit of consistent high quality e.g. wet coastal areas.
- **the performance and suitability of the variety for your district.** Some varieties perform better in certain districts. This can relate to disease susceptibility or physiological problems. For example, Murcott mandarin is so susceptible to the disease brown spot that it is almost impossible to grow this variety profitably in wetter coastal areas. Similarly, Ellendale mandarin is very susceptible to rind damage and fruit splitting in coastal areas.
- **management requirements of the variety.** Mandarins in particular have a very high management requirement because of the need for fruit thinning and extensive pruning. Navel oranges require

#### NOTE

The best varieties are those that are well known and accepted in the marketplace. Placing too many new varieties on the market confuses consumers and reduces the market performance of established varieties.

very good irrigation management and Valencia oranges require fruit thinning for the export fresh fruit market. Where high levels of crop management cannot be provided, these varieties are best avoided.

- **calculated prospects for the variety.** Although this involves a lot of ‘crystal-ball gazing’, some varieties appear to have better prospects than others. Early and late maturing varieties have an obvious marketing edge and seedless varieties will have good future marketing opportunities. Our assessment of the prospects for most of the main varieties is shown later in this section.

It is obvious that no one or two varieties will approach all of the ideals. Consequently, variety selection is a balanced judgement based on choosing a number of different varieties that spread the risk and workload.

## Characteristics of the main varieties

### Oranges

Variety	Harvest time throughout Queensland	District suitability	Main markets	Comments
Washington Navel	late March to June	Inland, coastal	Domestic fresh fruit. Minor export fresh fruit. Not suitable for processing.	Fruit are seedless and have excellent eating quality. Trees are not tolerant of difficult growing conditions. Very prone to excessive fruit drop during November, December and January. The major cause is the hot dry conditions experienced during this period combined with poor irrigation management. Also susceptible to navel end splitting from irregular watering. Well managed Irrigation is essential, particularly from August to December.
Joppa	April to July	Inland, coastal	Mainly juicing. Limited domestic fresh fruit.	Grown mainly in coastal areas for juicing. Not as acceptable for the fresh fruit market as other oranges. Vigorous, consistent cropper under most conditions. Seeded.
Late Valencia	July to October	Inland, coastal	Domestic fresh fruit and major export fresh fruit. Juicing.	Grows well in all districts. Multi-purpose variety. Best juicing orange as it has a deep orange coloured juice. Paler skin colour. Seeded. Requires fruit thinning to get fruit size suitable for export. Prone to biennial bearing in poorly managed trees.
New navel varieties e.g. Navelena, Newhall, Fischer	March to June	Inland, coastal	Domestic fresh fruit. Minor export fresh fruit. Not suitable for processing.	As for Washington navel above. Advantage over Washington navel is slightly earlier maturity.

### Mandarins

Imperial	late March to early May	Inland preferred	Domestic fresh fruit	Small, pale yellow fruit with good flavour and flesh texture. Seeded. A vigorous, heavy cropper which starts alternate bearing from about year 7. Fruit thinning is essential during heavy crop years to obtain satisfactory fruit size. Fruit must be clipped and not plucked from the tree. High level of management required.
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Variety	Harvest time throughout Queensland	District suitability	Main markets	Comments
<b>Mandarins (cont)</b>				
Beauty of Glen Retreat (Glen)	May to the end of June	Inland only	Domestic fresh fruit	Good fruit quality and bright orange colour. Seeded. Sets heavy crops. Fruit thinning is essential to produce large fruit. Declining in popularity.
Emperor of Canton (Emperor)	May to July	Coastal only	Domestic fresh fruit	Good colour. Seeded. Vigorous, heavy cropper. Very susceptible to brown spot disease in wetter coastal areas. Puffiness can be a problem.
Hickson	May to June	Inland preferred	Domestic fresh fruit and major export fresh fruit	Consistent crops of large fruit with good colour and flavour. Seeded. Susceptible to crotch rot which can kill trees.
Ellendale	June to August	Inland only	Domestic fresh fruit and major export fresh fruit	The main export variety. Large fruit with high acidity. Seeded. Fruit susceptible to rind damage and splitting on the coast. Can have problems with puffiness and fruit drop if not well managed. Branches are susceptible to splitting at the crotch with a heavy crop load.
Murcott	July to September	Inland only	Domestic fresh fruit and major export fresh fruit	Dark coloured, sweet, seedy fruit. Outside fruit is prone to sunburn from October to February. Fruit must be thinned to obtain satisfactory fruit size and avoid overbearing. Coastal plantings are very susceptible to brown spot disease.
Ellenor	late May to June	Inland only	Export fresh fruit	A tangor which is a hybrid of Ellendale and Thorny. Good colour, sweet and juicy. Very similar to Ellendale without the high acid but is smaller in size. Seeded.
Nova	April to June	Inland only	Export fresh fruit	A tangelo hybrid. Yellow to orange skin, good flavour, but not as juicy as other varieties. Seeded.
Sunburst	April to May	Inland only	Export fresh fruit	Excellent colour, but tends to hold its acidity too long into maturity in most production areas. Seeded.
Fremont	March to May	Inland, coastal	Export fresh fruit	Produces heavy crops of small fruit with excellent colour and flavour. Fruit must be thinned but still difficult to produce marketable sized fruit.
Success	May to June	Inland preferred	Domestic fresh fruit and export fresh fruit	A suspected hybrid with Hickson as one parent and so has many characteristics of Hickson. Seeded. Still being assessed but promising. Variety is covered by Plant Breeder Rights.
Clementine strains	Marisol – April de Nules – May to June	Inland preferred (coastal unknown)	Export fresh fruit	Seedless but must be grown at least 500 metres from other citrus to stay seedless. Performance still being assessed. Can be soft and puffy.

## Lemons

### True lemons

Villa Franca, Lisbon, Eureka	February to October	Inland only	Domestic fresh fruit and minor export fresh fruit. Juicing.	Best suited to drier districts. Produce heavy crops of good quality fruit. Trees are vigorous and mostly thornless. Seeded.
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### Lemon hybrid

Meyer	January to February (main early peak) but can produce through to November	Inland, coastal	Domestic fresh fruit and juicing	Less pronounced lemon flavour but has a high juice content. Performs well in coastal areas. Seeded.
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Variety	Harvest time throughout Queensland	District suitability	Main markets	Comments
<b>Grapefruit</b>				
Marsh	March to August	Inland, coastal	Domestic fresh fruit and juicing	Healthy, well-managed trees produce heavy crops of large, seedless or almost seedless fruit with a light coloured rind and a pale flesh. Most trees become infected with stem pit disease, reducing tree vigour and fruit size.
Oroblanco (Golden Sweetie)	March to August	Inland preferred (coastal unknown)	Domestic fresh fruit	Still being assessed. Appears to produce well flavoured, low acid fruit maturing slightly earlier than Marsh. Seedless if grown in isolation. Has a slightly thicker rind than Marsh and remains green longer.
Thompson Pink (Pink Marsh)	March to August	Inland preferred (coastal unknown)	Domestic fresh fruit (possible minor export)	Still being assessed. Similar to Marsh and appears to mature slightly earlier. Has a very slight pink tinge to the segment walls of the flesh.
Ruby group (Ruby Red, Star Ruby, Rio, Flame, Henderson)	May to July	Inland preferred (coastal unknown)	Domestic fresh fruit (possible minor export)	Still being assessed. Pink to red fleshed fruit, the colour intensity of the flesh and skin varying with temperature. Best colour in warmer climates. Seedless.
<b>Limes</b>				
Tahitian lime	harvested over many months	Inland, coastal	Domestic fresh fruit	Produces a heavy summer crop and a lighter winter crop. Susceptible to styler end rot which can be avoided by harvesting fruit while still green. Seedless.
West Indian lime	harvested over many months	North Qld only	Domestic fresh fruit	Much stronger lime flavour than the Tahitian, but fruit is smaller and less juicy. Major problem is susceptibility to citrus tristeza virus which reduces tree vigour. Can be grown true to type from seed.
<b>Specialty oranges</b>				
Maltese blood orange	May to July	Inland preferred	Specialty retailers	Poor overall fruit colour, best in hot climates with cold nights
Rough Seville	April to July	Inland, coastal	Processing only	A sour orange—grown to supply a limited factory demand for marmalade production.

## Our comments on current prospects

### Oranges

#### Navels

#### Major bonuses:

- Established market reputation and well known by consumers.
- Fairly consistent prices.

#### Major problems:

- Very limited export trade at present.
- Lowest return per hectare of all citrus except grapefruit.

## Valencia

- Difficult to grow well in Queensland because it drops fruit very easily particularly in our harsh spring conditions.

### Major bonuses:

- Established market reputation and well known by consumers.
- Established Japanese export market with current good prices.

### Major problems:

- Risky if the export market disappears as prices for domestic fresh fruit and juicing are relatively low.
- Difficult and expensive to meet Japanese export market requirements unless you are a large grower or part of a cooperative.
- Has a very high management requirement to produce fruit satisfactory for export. Requires thinning, extra black spot sprays, black spot monitoring and so on.

## Mandarins

### Imperial

### Major bonuses:

- Generally the earliest mandarin onto the market and therefore consistently achieves good prices.
- Established market reputation and well known by consumers.
- Very good marketing proposition as it has excellent flavour, is sweet with low acid, is easy to peel and is almost seedless. Good children's fruit.

### Major problems:

- As it is restricted to the domestic market, increased plantings could oversupply the available market with consequent lower prices.
- Skin is soft and marks very easily. Susceptible to degreening burn if not handled properly.
- Has a very high management requirement. Fruit must be thinned to achieve satisfactory size and to avoid overcropping and subsequent alternate bearing. Trees must be rigorously pruned to reduce fruit marking. Also very susceptible to spined citrus bug in inland areas.

**Murcott**

- Rootstock overgrowth on Troyer rootstock is a possible future problem particularly in trees that are not well managed.

**Major bonuses:**

- Considered the most exportable of all mandarins and consequently has enormous export potential.
- The latest maturing of the main mandarin varieties and therefore consistently achieves good prices.
- Established market reputation and well known by consumers. Very good marketing proposition as it has excellent flavour and appearance.

**Major problems:**

- Not yet thoroughly established and tested in all export markets because of insufficient production.
- Has a bad growth habit requiring more training and pruning than most other varieties. Fruit are also very susceptible to sunburn.
- Has a very high management requirement. Fruit must be heavily thinned to achieve satisfactory size and a special nutrition program is essential.
- Ideal rootstocks not yet available.

**Other mandarins****Major bonuses:**

- Excellent export potential. All have various niches, have sold well and are in demand by exporters.
- Prices are sound and reasonably consistent without reaching the spectacular heights of Imperial and Murcott.
- Ellendale and Hickson have an established market reputation and are reasonably well known by consumers.

**Major problems:**

- With the exception of Ellendale and Hickson, most are not yet thoroughly established and tested in export markets because of insufficient production.
- Varieties such as Ellendale and Hickson may vary significantly in fruit quality and hence market acceptance from year to year. Both have significant problem areas requiring careful management.

- With the rash of new mid-season varieties such as Success, the older established varieties Ellendale and Hickson are vulnerable to competition and possible replacement.

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## Lemons, limes and grapefruit

### Lemons

#### Major bonuses:

- Fairly solid performers on the domestic market particularly for Eureka and early Meyer fruit.
- Relatively easy to grow without the high management requirements of oranges and mandarins.
- Good export potential for Eureka to Japan if chilling injury problems could be overcome.

#### Major problems:

- Rainfall makes manipulation of cropping for out of season production unreliable in most seasons.

### Limes

#### Major bonuses:

- Growing interest in and demand for limes in food service industries.
- Reasonable potential as a competitor in the early lemon market.
- Relatively easy to grow without the high management requirements of oranges and mandarins.

#### Major problems:

- Domestic markets are easily oversupplied for a large part of the season and prices can be volatile.
- Rainfall makes manipulation of cropping for out of season production unreliable in most seasons.

### Grapefruit

#### Major bonuses:

- Relatively easy to grow without the high management requirements of oranges and mandarins.
- Growing market interest in the pink and red fleshed varieties.

#### Major problems:

- Very low returns compared to most other citrus.



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**Note:** These are our comments only and as such represent only one opinion on variety selection. Don't rely solely on this one opinion. Also seek opinion from experienced growers, consultants, citrus nursery-men and marketers. Growers investigating the export market should also consult exporters and citrus export organisations.

Because the variety position will be volatile in the future, our advice is to select the most appropriate varieties and then plant at high density to concentrate your production for the first ten years into as small an area as possible. This not only improves your early cash flow per unit area but also makes your management more efficient. Importantly, it leaves you with spare land to immediately plant to new varieties when and if they become available.



## Selecting rootstocks

*As citrus trees are budded or grafted, the rootstock is the tree's lifeline to the water and nutrients required to sustain it. Tree size, tree yield, tree longevity and fruit quality all depend on the rootstock. Selecting the right rootstock is therefore critical in the success of commercial citrus growing. It is not easy as there are a number of different rootstocks and a number of differing opinions on which one is the best. This section will help you make an informed decision about selecting rootstocks.*

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### Characteristics of the main rootstocks

#### Rough lemon

##### Major bonuses:

- vigorous rootstock with an extensive root system producing large trees
- best for light sandy soils
- produces very good yields
- trees start to bear at an early age
- produces large size fruit which mature early
- tolerant of exocortis viroid
- drought tolerant
- suitable for a wide range of varieties except mandarins

##### Major problems:

- highly susceptible to blight, root and collar rot
- highly susceptible to citrus nematode
- susceptible to salt damage
- does not tolerate poorly drained soils
- produces fruit with below average internal and external quality

#### Sweet orange

##### Major bonuses:

- produces fruit of good external and internal quality
- highly resistant to blight
- produces trees with a long life which produce well in their later years

- tolerant of exocortis viroid
- suitable for a wide range of oranges and mandarins

**Major problems:**

- trees grow more slowly and produce less fruit in their early years than rough lemon
- disliked by some nurseries because of slow growth
- highly susceptible to root and collar rot
- highly susceptible to citrus nematode
- susceptible to sweet orange strain of tristeza
- fairly susceptible to salt damage
- does not tolerate poorly drained soils

**Cleopatra mandarin****Major bonuses:**

- medium to high yielding potential
- tolerant of exocortis viroid
- excellent salt tolerance
- performs well in lime soils
- tolerant to blight
- produces fruit with good internal and external quality

**Major problems:**

- more difficult than other rootstocks to establish
- fruit size may be slightly reduced
- medium susceptibility to root and collar rot
- highly susceptible to citrus nematode
- limited to use for some mandarins

**Poncirus trifoliata Major bonuses:****(tri or trifoliata)**

- smaller trees and can be planted closer
- excellent resistance to root and collar rot
- excellent resistance to citrus nematode
- some tolerance to blight
- very good tolerance of poorly drained soils
- produces excellent quality fruit

**Major problems:**

- very susceptible to salt damage
- very susceptible to exocortis and requires budwood completely free of the viroid
- disliked by some nurseries because of slow growth
- limited suitability to limes and oranges

**Troyer citrange****Major bonuses:**

- good resistance to root and collar rot



- good resistance to blight
- produces fruit of very good quality
- produces relatively good yields
- matures Imperial fruit earlier than other rootstocks
- suitable for a wide range of citrus varieties

**Major problems:**

- slightly susceptible to salt damage
- moderately susceptible to citrus nematode
- very susceptible to exocortis and requires budwood completely free of the viroid
- long term incompatibility with Imperial mandarin
- incompatible with Eureka lemon

**Swingle citrumelo Major bonuses:**

- good resistance to root and collar rot
- excellent resistance to citrus nematode
- reasonable resistance to salt damage
- produces good yields of large fruit of excellent quality
- very vigorous and trees crop at an early age
- very tolerant of poorly drained soils
- good frost tolerance
- suitable for a wide range of citrus varieties

**Major problems:**

- incompatible with Eureka lemon
- some incompatibility problems with Imperial
- performs poorly in lime soils
- with Washington navel, yield is lower for equivalent tree size when compared with Troyer

**Benton citrange Major bonuses:**

- good resistance to root and collar rot
- some tolerance to salt damage
- compatible with Eureka lemon
- disliked by nurseries because of slow growth and tendency to bush

**Major problems:**

- very susceptible to exocortis and requires budwood completely free of the viroid

**Cox and Frazer**

- new hybrids currently under evaluation for Eureka lemon. Little information as yet.

## A process for rootstock selection

Here is a broad process for selecting rootstocks:

1. First select the scion variety you wish to grow.
2. Then assess the depth and drainage of your soil and whether the site has grown citrus previously. A listing of rootstocks against these criteria is shown in Table 1 below.
3. Then check the salt level of your irrigation water. Rootstocks preferred for use where there is a salt problem are asterisked in Table 1.
4. Where there are a number of suitable rootstocks that meet both of these requirements, a final selection is made on how the rootstock affects yield and fruit quality of the scion variety. Some brief details on the main effects are shown in Table 2.

**Table 1.** Suitable rootstocks for different soil conditions (those with an asterisk are suggested where a salty water problem exists)

Scion variety	Suggested rootstocks where topsoil is well-drained (greater than 75 cm deep) and has not previously grown citrus	Rootstocks to use in replant citrus land or where soil is less well-drained (less than 75 cm deep)
Oranges	Rough lemon Troyer citrange* Sweet orange* Swingle citrumelo**	Troyer citrange* Poncirus trifoliata Swingle citrumelo**
Ellendale mandarin	Troyer citrange* Sweet orange*	Troyer citrange* Poncirus trifoliata
Murcott mandarin	Rough lemon Cleopatra mandarin** Troyer citrange* Sweet orange* Swingle citrumelo**	Troyer citrange* Swingle citrumelo**
All other mandarins	Cleopatra mandarin** Troyer citrange* Sweet orange*	Cleopatra mandarin** Troyer citrange*
Villa Franca and Lisbon lemons	Rough lemon Troyer citrange*	Troyer citrange*
Eureka lemons	Rough lemon Frazer (hybrid)* Cox (hybrid)* Benton*	Frazer (hybrid)* Cox (hybrid)* Benton*
Meyer lemons	Rough lemon	None proven. Suggest soil fumigation with either rough lemon or cleo mandarin**
Grapefruit	Rough lemon Swingle citrumelo**	Troyer citrange* Swingle citrumelo**
Limes	Rough lemon Troyer citrange* Poncirus trifoliata	Troyer citrange* Poncirus trifoliata

\*\* — preferred for medium salt problem

\* — preferred for minor salt problem

NOTE: Rootstock overgrowth of Imperial on Troyer can be a problem under conditions where the tree is stressed from overcropping, poor nutrition, poor watering or waterlogging. The effect is a slow loss of productivity and decline of the tree. Because the combination has the advantage of larger and earlier fruit, it is still recommended. However, stress to the tree needs to be minimised and replanting expected sometime after 15 years. Swingle citrumelo produces a similar reaction and may commence a similar decline. Although large areas have been planted, the long term reaction under all management conditions is not yet clear. For this reason, we are not recommending Swingle until further experience is obtained.

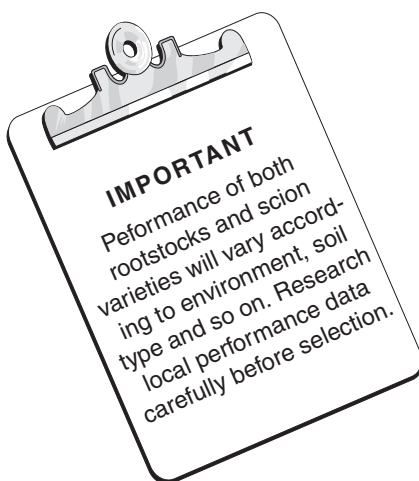
**Table 2.** Effects of rootstocks on fruit quality

Rootstock	Fruit maturity	Fruit size	Rind thickness	Total soluble solids	Acid content	Juice content
Rough lemon	early	large	thick	low	low	low
Sweet orange	mid to late	medium to large	medium	medium to high	medium	high
Cleopatra mandarin	mid to late	medium	thin	medium	medium	high
Poncirus trifoliata	late	medium to large	thin	high	high	high
Troyer citrange	mid	medium to large	thin	high	medium	high
Swingle citrumelo	early to mid	large	thin	high	medium	high

Adapted from *Quality Management Guide* by Brian Beattie and Lou Revelant (1992), Australian Horticultural Corporation.

### A final note on rootstocks

Note that the ratings in the above tables are based on the best experience available at the time and some of this is very limited. It represents only one opinion on rootstock selection. Don't rely solely on this one opinion. Also seek opinion from experienced growers, consultants and citrus nurserymen.





## Nutrition

*Good plant nutrition is one of the vital components of achieving good yields and fruit quality. Both deficiencies and excesses of plant nutrients can adversely affect fruit yield and quality. Fertiliser use has to be carefully managed to ensure a balanced supply of all nutrients is maintained. Here are the important things you need to know:*

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Understanding the important nutrients .....	36
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### **Why nutrition needs to be carefully managed**

The unmanaged approach to fertilising citrus involves applying fertiliser throughout the season without knowing whether the soil or the plant needs it or not. This can lead to excessively low or high levels of some nutrients in the soil and plants. This can cause a number of problems:

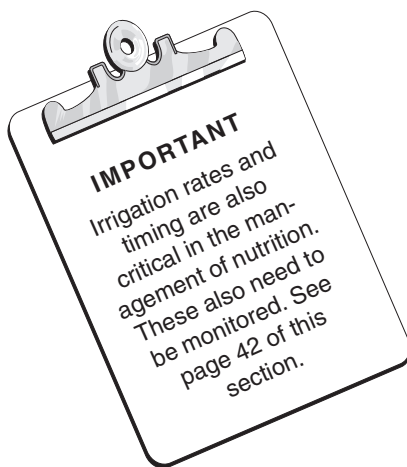
- reduced yields from nutrient imbalance
- excessive leaf flushing at the wrong time, reducing fruit quality
- lower fruit quality (thicker skins, lower juice levels, smaller fruit) from nutrient imbalance
- greater susceptibility to conditions such as creasing, styler end rot, degreening burn and some pests such as branch borers
- contamination of groundwater from excess nutrients being leached out of the root zone.

In addition, blanket fertiliser applications fail to recognise that different varieties have different fertiliser needs. Consequently, a blanket fertiliser rate tends to be too much for some and too little for others.

Clearly, nutrient levels in both the soil and plant need to be more carefully monitored to avoid these problems. Nutrient monitoring improves yield and fruit quality, reduces fertiliser cost and is kinder on the environment.

### **The managed approach—monitoring nutrients**

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



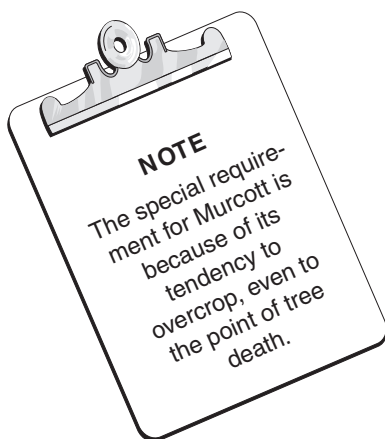
- **Pre-plant soil analysis.** This ensures that soil nutrient levels are at their optimum before planting. It is particularly important to allow for the adjustment of insoluble nutrients such as phosphorus and calcium which are difficult to adjust once the trees are in the ground.
- **Annual leaf analysis in bearing trees.** This allows the fertiliser program to be fine-tuned each year to keep all nutrients within the optimum range. It allows variables such as the season, the crop load and the condition of the tree to be taken into account.
- **Regular soil analysis in bearing trees.** This ensures that soil pH is kept within the desired range and allows a watch to be kept on the important balance between pH, calcium, magnesium and potassium.

## Understanding the important nutrients

### Nitrogen

Nitrogen is the most important nutrient in citrus growth and development and is required in the largest amounts. In fact, citrus have the highest nitrogen requirement of all the commonly grown fruit trees. However, this often leads to a temptation to apply too much. Excess application delays maturity, decreases yields and affects fruit quality by producing thicker rinds, reduced size, lower juice content, increased juice acidity and increased breakdown after harvest.

In bearing trees, what is required is just sufficient nitrogen to grow a healthy spring flush to provide the fruiting wood for the coming season. Further growth flushes are undesirable as they unnecessarily increase tree size and divert valuable nutrients from the developing fruit. This means that for all varieties except Murcott, all the nitrogen fertiliser is applied in one application in winter before the spring flush. For Murcott, periodic light applications from June to March are preferred. Use leaf analysis and crop load to guide fertiliser rates.



### Phosphorus

Like most tree crops, citrus has a very low requirement for phosphorus, particularly in the sandy loam soils where most Queensland citrus is grown. As phosphorus is readily available in these soils, deficiencies are rare. In general, annual application of phosphorus fertiliser is a waste of money except in heavier clay soils. Banding of phosphorus fertiliser in a one metre wide strip along the tree row generally will meet the tree's needs for a number of years in most soils. Use leaf analysis to monitor phosphorus levels.

### Potassium

Citrus varieties vary more in their potassium requirements than for any other nutrient. It is a major component of fruit and therefore has a

significant impact on fruit size and fruit acidity. Varieties producing smaller fruit such as the early mandarins Imperial, Nova, Sunburst and Fremont, have a higher requirement than the larger highly acid fruit such as Ellendale and Wallent mandarins and grapefruit. Joppa and Valencia oranges also benefit from higher potassium as these often have a small fruit size problem. On the other hand, Navels have a lower requirement because fruit size is generally not a problem and low acidity is required for early harvest.

Annual applications of potassium fertiliser are generally required with most or all applied in the spring to help build size in the developing fruits. Leaf analysis is vital for managing this nutrient. For Murcott, apply potassium in periodic light amounts in conjunction with the nitrogen.

### **Calcium**

While the need for calcium is high, calcium deficiency is rare in citrus. However, it is implicated as a possible factor in conditions such as creasing, navel end splitting and stylar end rot. Problems generally only occur where soil pH is low or where excessive leaf growth from high nitrogen reduces calcium uptake. Where calcium levels become too high, the uptake of magnesium and potassium can be significantly reduced.

Because of these links with pH, magnesium and potassium, regular soil analysis combined with leaf analysis is recommended. Application of calcium fertiliser in the form of lime, dolomite or gypsum is generally only necessary once every few years. A soil pH of 6.0 to 6.5 is considered optimum.

### **Magnesium**

Although it is not required in large amounts, magnesium is an important nutrient in developing the green substance of the leaves and ensuring effective photosynthesis. Deficiency is rare except in the leached, acid, sandy soils of the coast. It is best monitored by leaf and soil analysis and corrective action applied only where results indicate a need.

### **Trace elements**

Zinc and boron are the main trace elements affecting citrus yield and quality. As both nutrients do not easily re-translocate within the tree, there must be either a ready supply from the soil or foliar sprays need to be applied. Use leaf analysis to monitor levels and back this up with soil analysis every second year or so. Where foliar sprays are used, apply these to the developing spring flush.

## A program for nutrition management

### 1. Before planting

Do a complete soil analysis before planting to enable all nutrients to be adjusted to their appropriate levels throughout the intended root zone. This is particularly important for the relatively insoluble nutrients such as phosphorus, calcium, zinc and copper as these are best applied and then worked into the entire root zone. Obviously, it is difficult to do this after the trees have been planted.

Get the results of the soil analysis interpreted by a representative of the analysis laboratory or an agronomist or citrus consultant. They will recommend appropriate fertilisers and rates to bring the levels of all nutrients within the desired ranges. The optimum soil nutrient levels to aim for are shown in Table 1.

**Table 1.** Optimum soil nutrient levels

Element	Optimum soil levels
pH (1:5 water)	6.0 - 6.5
Organic carbon	more than 3.0%C
Nitrogen	not applicable*
Sulphate sulphur (Phos-extr)	more than 15 mg/kg S
Phosphorus (bicarb-Colwell)	more than 80 mg/kg P
Potassium (Amm. acetate)	more than 0.37 meq/100 g K
Calcium (Amm. acetate)	more than 5 meq/100 g Ca
Magnesium (Amm. acetate)	1.6 meq/100 g Mg
Sodium (Amm. acetate)	less than 1 meq/100 g Na
Chloride	less than 250 mg/kg Cl
Conductivity (sat.extract equiv)	less than 2 dS/m
Copper (DPTA)	0.3 - 10 mg/kg Cu
Zinc (DPTA)	2 - 10 mg/kg Zn
Manganese (DPTA)	4 - 45 mg/kg Mn
Iron (DPTA)	more than 2 mg/kg Fe
Boron (Calcium chloride)	more than 1 mg/kg B

\* —nitrogen is difficult to measure in a meaningful way and is not normally applied before planting

### 2. Young, non-bearing trees

If nutrient levels were adjusted properly before planting, there will be little need to apply any fertiliser other than nitrogen and potassium fertilisers for the first three years.

Don't start fertilising until the young trees have started to put on new growth. Then fertilise little and often, at least once every month from September to May. In larger orchards, application every second month

is more practicable. The recommended annual application per tree per year of age is 100 g of nitrogen and 50 g of potassium. This is equivalent to about 220 g of urea and 125 g of sulphate of potash per tree per year of age. Alternatively, use a mixed tree fertiliser plus urea. Multiply this figure by the age of the tree in years to calculate the annual requirement per tree. For example, a three year old tree would require 660 g of urea and 375 g of sulphate of potash. If applied once a month from September to May, this equates to nine applications of approximately 75 g of urea and 40 g of sulphate of potash.

Spread the fertiliser in a broad ring around the tree extending 50 cm beyond the canopy. Keep the fertiliser 10 cm away from the trunk. Alternatively, apply through the irrigation system (fertigation).

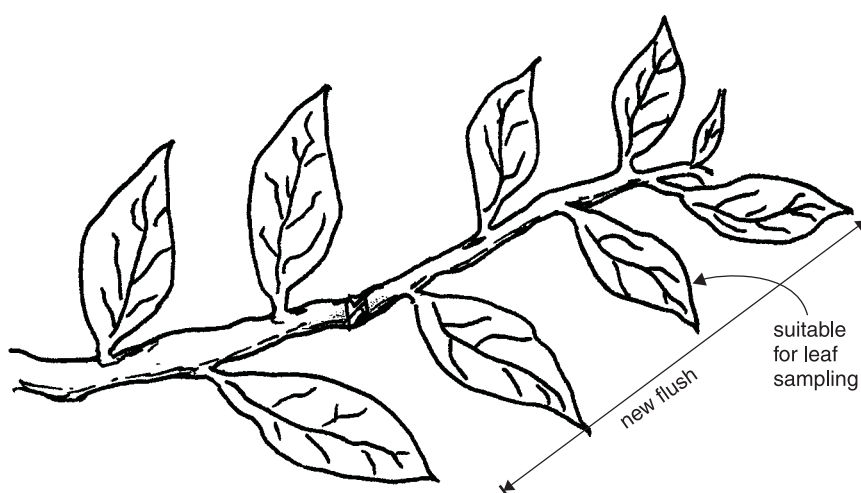
Newly planted trees generally benefit from an annual copper spray for the first three years after planting. Use copper oxychloride (400 g/100 L water) or copper hydroxide (200 g/100 L water). Apply in the spring.

Preferably, do another soil analysis in the second or third year after planting to check soil nutrient status.

### Bearing trees

From bearing onwards (normally considered at year 4), base all fertiliser application on leaf and soil analysis. Do leaf analysis each year in February/March. Preferably do a soil analysis each year at the same time, but at least every two to three years.

For leaf analysis, sample the middle leaf from a non fruiting terminal of the previous spring flush, that is when the flush is about five to seven months old (Figure 1). It is important to sample the right leaves otherwise results can be misleading. If you are not experienced, seek advice from a local citrus consultant.



**Figure 11.** The correct leaf to sample for leaf analysis

Get the results of the leaf analysis (and soil analysis where appropriate) interpreted by a representative of the analysis laboratory or an agronomist or citrus consultant. They will recommend appropriate fertilisers and rates to bring the levels of all nutrients within the desired ranges.



The optimum leaf nutrient levels to aim for are shown in Table 2. Optimum soil nutrient levels were shown previously in Table 1.

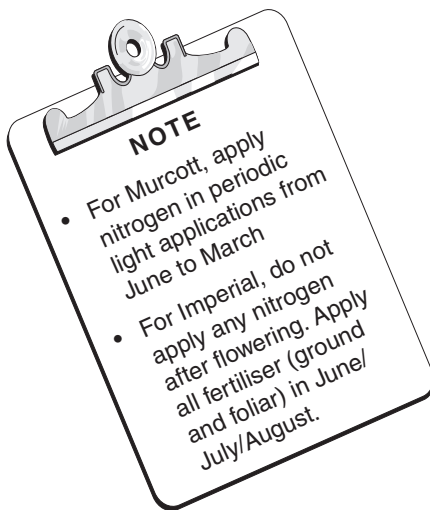
**Table 2. Optimum leaf nutrient levels**

Element	Optimum leaf levels
Nitrogen	2.4 - 2.6% N
Sulphur	0.20 - 0.40% S
Phosphorus	0.12 - 0.16% P
Potassium	0.70 - 0.90% K (Navel, Ellendale, grapefruit) 0.90 - 1.20%K (Joppa, Valencia, other mandarins) 1.20 - 1.70%K (Imperial, Murcott, Emperor, Glen, lemons)
Calcium	3.00 - 6.00% Ca
Magnesium	0.25 - 0.60% Mg
Sodium	less than 0.16% Na
Chloride	less than 0.30% Cl
Copper	5.0 - 10.0 mg/kg Cu
Zinc	25 - 100 mg/kg Zn
Manganese	25 - 100 mg/kg Mn
Iron	60 - 120 mg/kg Fe
Boron	30 - 100 mg/kg B
Molybdenum	0.10 - 3.00 mg/kg Mo

Important information on timing and other aspects of fertiliser application are shown in Table 3.

**Table 3. Fertiliser timing and comments**

Nutrient	Main fertilisers	Timing of fertiliser	Other comments
Nitrogen	urea, nitram, Granam, sulphate of ammonia, blend	Apply all nitrogen in one or two applications in June/July	Soil applied. Generally required every year. Base on leaf analysis results. Do not exceed 200 kg of nitrogen (equivalent to about 425 kg urea) per hectare.
	potassium nitrate	Apply to Murcott (December to March) and Imperial (July/August)	Foliar sprays. Generally required every year because of crop load. Apply up to four sprays for Murcott and one for Imperial.
Phosphorus	superphosphate, DAP, blend	Apply at any convenient time but preferably before the wet season	Soil applied. Rarely required every year. Base on leaf analysis results.
Potassium	miriate of potash, sulphate of potash, blend	Apply between August and October in one or two applications	Soil applied. Generally required every year. Base on leaf analysis results. Navel, Ellendale and grapefruit have a relatively low requirement while Imperial, Murcott, Emperor, Glen and lemons have a high requirement. Joppa and Valencia and other mandarins have a medium requirement.



Nutrient	Main fertilisers	Timing of fertiliser	Other comments
Potassium	potassium nitrate	Apply to Murcott (December to March) and Imperial (July/August)	Foliar sprays. Generally required every year because of crop load. Apply up to four sprays for Murcott and one for Imperial.
Calcium	lime, dolomite, gypsum	Apply at any convenient time	Soil applied. Generally required once every two to three years. Base on leaf analysis and soil analysis results. Adjust pH to 6.0 to 6.5.
Magnesium	dolomite, granomag	Apply at any convenient time	Soil applied. Rarely required every year except in sandy, acid coastal soils. Base on leaf analysis and soil analysis results. Adjust pH to 6.0 to 6.5.
	magnesium sulphate or magnesium nitrate	Spray onto spring flush	Foliar spray. Magnesium sulphate best applied in mixture with calcium nitrate. Short-term measure while soil levels are being investigated.
Zinc	zinc sulphate heptahydrate	Spray onto spring flush	Foliar spray. Generally required every year. Base on leaf analysis results. If persistently low, investigate soil levels.
Boron	Solubor	Spray onto spring flush	Generally required every second or third year. Base on leaf analysis results.
Other trace elements e.g. manganese	various	Apply at any convenient time	Rarely required every year. Base on leaf analysis results.



Rates to use for  
foliar sprays  
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For soil applied fertilisers, spread the fertiliser over the whole area of the orchard as mature roots extend to the middle of the rows.



## Irrigation and water monitoring

*Although the trees may not show it, water stress at critical times in the development of the crop can dramatically affect fruit yield and quality. Careful management of irrigation is therefore a key factor in achieving good orchard performance. Here are the main things you need to know:*

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Irrigation must No. 1—a good irrigation system .....	42
Irrigation must No. 2—a monitoring system .....	43
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### **The importance of getting irrigation right**

Citrus trees are finely balanced in how they react to water management. On the one hand, too little water causes major problems such as:

- lower yields from restricting the spring growth flush and reducing fruit set
- increased early fruit drop particularly in Navels
- lower fruit quality from reduced fruit size, increased splitting, induced calcium and boron deficiencies, and increased incidence of other fruit problems such as creasing, styler end rot and degreening burn.

To guard against the problem of underwatering, it is easy to go to the other extreme and apply too much. This reduces yield through reducing soil aeration, increases the incidence of root and collar rot diseases and reduces fruit quality. Some rootstocks also have a low tolerance of waterlogging. Another major but often forgotten problem is that overwatering leaches fertiliser out of the root zone. This not only wastes fertiliser but also poses a serious environmental hazard of polluting groundwater with excessive amounts of nutrients.

### **Irrigation must No. 1—a good irrigation system**

The first essential requirement of efficient irrigation is a water supply and irrigation system capable of delivering the required amounts of water when needed without wasting your scarce water resource.

The best way to do this is to get a qualified irrigation designer to prepare an irrigation design plan. There are two preferred irrigation systems on which the plan can be based:

- Undertree minisprinklers with a microspray feature. The microspray feature is used for the first two years to limit water throw. Use sprinklers with an output of 80 to 250 litres per hour. Remember in the design of the irrigation system to allow capacity for the extra sprinklers to water your windbreak trees.
- T-tape trickle systems. For young trees, use one row of tape. When trees reach an age of about three to four years, a second row of tape is installed on the other side of the tree row. Trickle systems need to be very well designed to operate effectively and must be properly maintained to prevent blockages. High level filtration with sand filters is essential. Although trickle watering requires more careful management, it has some significant advantages. It uses much less water, provides more efficient wetting of the root zone and can be used to apply soluble fertilisers directly into the root zone of the plants.

Whatever system you use, it must be able to supply water to a depth of about 150 cm, as that is the normal depth that roots reach in the soil profile.

### **Irrigation must No. 2—a monitoring system**

The second essential requirement of efficient irrigation is a system to tell you when and how much water your crop needs. This is known as a monitoring or scheduling system. The importance of monitoring is confirmed by research which shows that water use can generally be reduced with monitoring, without affecting yield and fruit quality. It also makes sure you are applying enough water at the critical times and not overdoing it at other times.

A range of equipment and techniques are available for monitoring soil moisture and scheduling irrigation. The most common are the soil based systems using neutron soil moisture probes, tensiometers, or newly developed soil capacitance systems such as the Enviroscan. The other technique sometimes used is a climate based system based on estimates of evapotranspiration. The soil based systems are preferred and recommended. A brief comparison of the main systems is shown in Table 1.

Because citrus have the bulk of their roots in the top 75 cm of soil, any soil water monitoring device used for irrigation scheduling needs to concentrate on this part of the soil profile.

As soil moisture monitoring can be complex, the use of consultants is recommended, particularly when setting up the system.



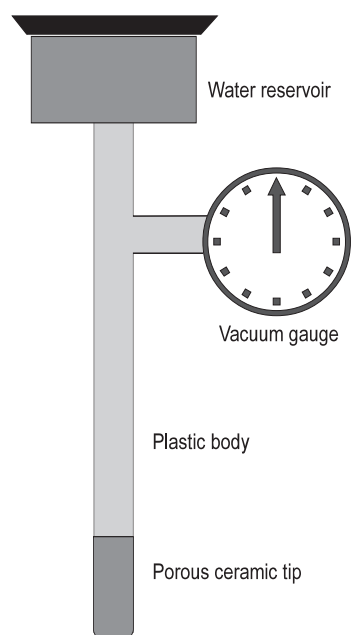
Irrigation consultants  
Section 6 page 6

**Table 1.** Comparison of main soil moisture monitoring systems

System	Advantages	Disadvantages
Tensiometers	<ul style="list-style-type: none"> <li>• Relatively cheap</li> <li>• Easy to install</li> <li>• Can be read by growers themselves</li> <li>• Continuous monitoring</li> </ul>	<ul style="list-style-type: none"> <li>• Labour intensive to collect and record data</li> <li>• Require regular maintenance</li> <li>• Can be inaccurate in extremely wet or dry soil</li> <li>• Less accurate in the top 10 cm of soil</li> </ul>
Neutron probe	<ul style="list-style-type: none"> <li>• Portable and can be moved around sites</li> <li>• Very reliable</li> </ul>	<ul style="list-style-type: none"> <li>• Not suitable for continuous monitoring</li> <li>• Equipment is expensive and contains radioactive material so generally requires use of a consultant who owns the equipment</li> <li>• Less accurate in the top 10 cm of soil</li> <li>• Less accurate in sandy soil because of low sampling frequency</li> </ul>
Capacitance probe e.g. Enviroscan	<ul style="list-style-type: none"> <li>• Continuous monitoring</li> <li>• Accurate at all depths and for all soils</li> <li>• Enables rapid reading and recording of results</li> </ul>	<ul style="list-style-type: none"> <li>• Expensive</li> <li>• Requires skill in interpreting data</li> </ul>
Evaporation pan	<ul style="list-style-type: none"> <li>• No in-field measurement required as system uses weather data to predict irrigation need</li> </ul>	<ul style="list-style-type: none"> <li>• Inaccurate as system ignores soil variability</li> </ul>

## Tensiometers

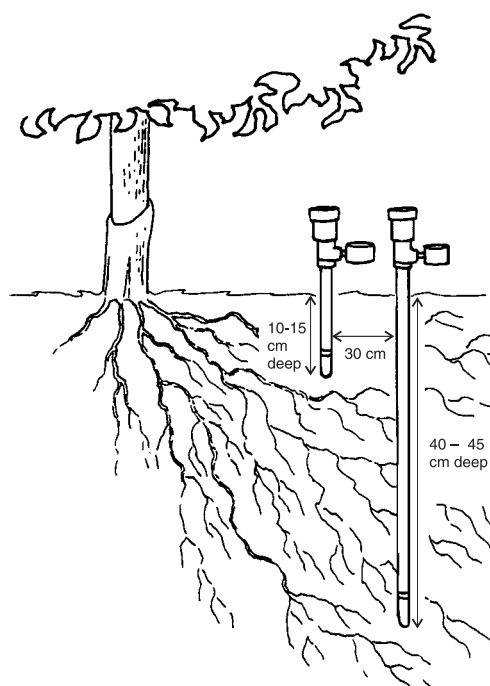
A tensiometer consists of four basic parts—a hollow tube filled with water and algaecide, a ceramic tip, a water reservoir and a vacuum gauge which reads water tension on a scale of 0 to 100 kPa or centibars (Figure 1). In wet soil, the vacuum gauge displays 0 to 5 kPa or centibars. As the soil dries over several days, water moves from inside the instrument, through the porous ceramic tip, into the soil. The gauge reading steadily increases, to a maximum of about 90 kPa or centibars. When the soil is re-wet after rain or irrigation, water moves from the soil back into the tensiometer and gauge readings fall.



**Figure 1.** Parts of a standard tensiometer

### Monitoring sites

Tensiometers are installed at monitoring sites throughout the orchard once trees are established. They are then left in place. Use at least one monitoring site for each variety or block. At each site, install two tensiometers - one 30 cm long tensiometer installed in the major root zone at a depth of about 10 to 20 cm, and one 60 to 90 cm long tensiometer below most of the roots at a depth of about 45 cm. Place tensiometers on the north-eastern side of trees, inside the dripline and at least 15 cm from the trickle tube. Placement of tensiometers is shown in Figure 2.

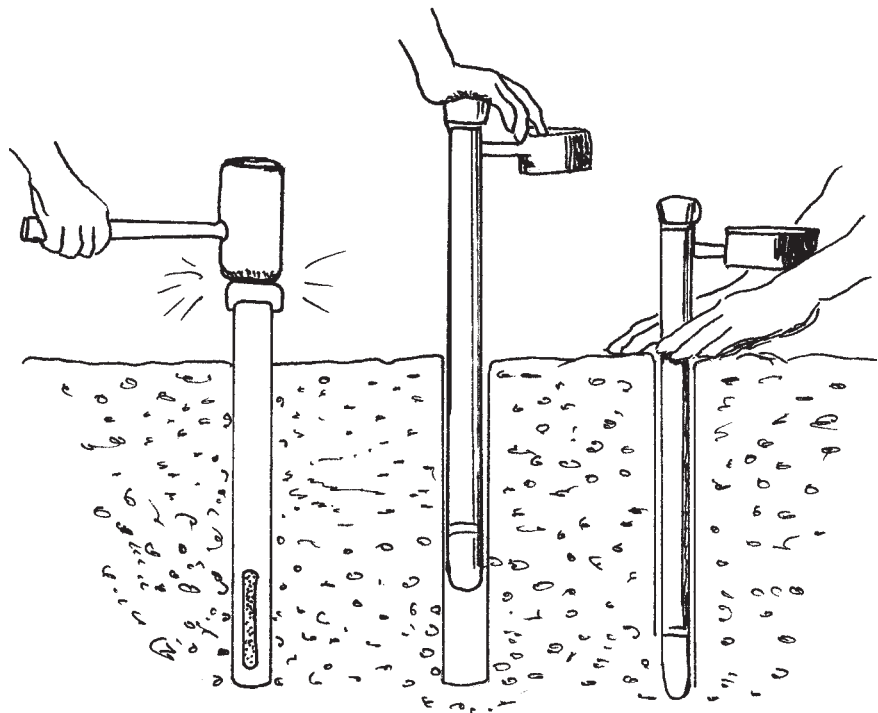


**Figure 2.** Tensiometer placement

## Installation

Assemble tensiometers and fill with good quality water (to which algaecide has been added). Leave them to stand in a bucket of water at least overnight, but preferably for one to two days. The water does not need to be pre-boiled. Tensiometers are more reliable if an appropriate vacuum pump is used to remove any air. Top up the tensiometers with more water if necessary. They are now ready to install.

Carry the tensiometers to the installation site with the tips either in water or wrapped in wet rags. Provided the ground is moist and well cultivated, the shallow tensiometer can simply be pushed into the soil to the 10 to 20 cm depth. Don't push too hard! The tips are strong, but can crack under excessive pressure. Only experience teaches how hard is too hard. At \$30 per tip, this can turn out to be an expensive lesson. If you encounter a hard soil layer, either take the tensiometer out and try somewhere else, or use the deep tensiometer procedure.



**Figure 3.** *Installing deep tensiometers*

To install the deep tensiometer, follow these instructions in conjunction with Figure 3. First make a hole to the required depth, keeping the excavated soil nearby in a pile. We have found a 50 mm (2 inch) auger the best tool. Place the tensiometer in the hole, over to one side. The next step is critical. Good contact between the ceramic tip and the surrounding soil is very important. Take the most crumbly, moist soil from the dirt pile and pack it around the tip at the base of the hole. A piece of 10 to 15 mm diameter dowel is useful for packing. Don't overcompact the soil into plasticine, but remove any large air gaps. Continue replacing soil until the hole is filled. It doesn't matter which

soil you use after you have packed the first 5 cm above the tip. Friable topsoil from a few metres away can be used to create a slight mound around the tensiometer. This minimises water draining down beside the tensiometer leading to false readings. Covers made from silver/blue insulation foil placed over the tensiometers minimise temperature fluctuations and algal growth. The gauge can be left exposed for easy reading.

The tensiometers are now ready to operate. Use the vacuum pump to again remove air bubbles. Tensiometers may take a few irrigation cycles to settle down, so don't take too much notice of the readings for the first few days. During this period, air gaps may appear in the tensiometer. Simply refill with algaecide-treated water. Within a week of installation, readings should rise and fall with irrigation/rainfall.

Clearly mark tensiometer locations otherwise they may fall victim to tractors and other equipment.

### Reading

Read tensiometers early in the morning before 8 am, preferably the same time each reading. Read at least twice a week but preferably every day or second day. Lightly tap the gauge before reading.

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



### Irrigating using tensiometers

Start watering when the shallow tensiometer reads 20 cb (in sandy soils) and 30 to 40 cb (in loam and clay loam soils). Stop watering when the reading on the deep tensiometer falls to 10 cb. Slightly lower readings should be used for trickle systems. Reposition tensiometers every second year in winter to the new dripline position. Once a week, remove any accumulated air and check that gauges are working using a vacuum pump. Refill tensiometers with clean water.

### Troubleshooting tensiometer problems

#### No water in the tensiometer; gauge reads 0

There is either a crack in the ceramic tip or a faulty seal. Fill the tensiometer with water and apply suction with a vacuum pump. A stream of large bubbles will indicate the problem area; usually a cracked tip or a missing o-ring.

#### Air entering over several days; gauge registering > 5

There is either a hairline crack in the tip, or a substantial air gap in the soil around the tip. Remove the tensiometer; and if there are no obvious tip cracks, re-install the tensiometer. If the problem persists, replace the tip.



### **No change in readings over several days**

The gauge may be faulty or blocked. Check the gauge is working by:

1. applying suction to the tensiometer with a vacuum pump
2. removing the gauge, rinsing with clean water and sucking it. If the needle does not move, there is a problem with the gauge.

### **Tensiometer readings increase beyond 80 then fall to 0, accompanied by air in the tensiometer.**

The soil has become too dry for the tensiometer to operate. After irrigation, refill the tensiometer and treat as if it had just been installed. If this happens frequently, consider whether you are under-irrigating. If you are happy with your irrigation, try installing the shallow tensiometer slightly deeper. This problem should never occur with the deep tensiometer!

## **The neutron probe**

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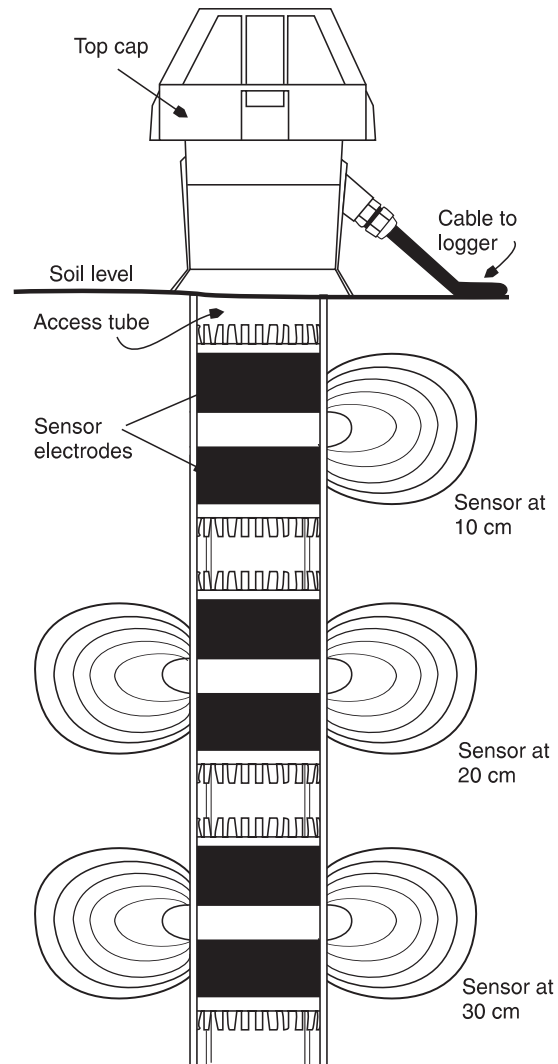
This is a very sophisticated device consisting of a probe containing a neutron source and a detector. A number of access holes are set up in the orchard and the probe is brought to these sites at regular intervals. When the probe is lowered into the access holes, neutrons from a radioactive source are emitted into the soil profile. When these fast neutrons collide with hydrogen atoms in water, they slow down dramatically and are deflected back to the detector which responds to slow neutrons only. If the soil is dry, the neutrons do not slow down and are therefore not detected. Readings are taken at various depths to provide an overall view of soil moisture within the profile.

As the probe is very expensive, it is generally used only by consultants to monitor and provide recommendations for watering. Although it is more accurate than tensiometers, its value is dependent on how regularly the consultant visits and makes readings.

## **The Enviroscan capacitance probe**

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This is a continuous moisture monitoring device based on capacitance sensors. The sensors are mounted on probes which have slots every 10 cm to accommodate the snap-in sensors. These probes are then placed within vertical PVC access tubes installed semi-permanently in the orchard. The probes are generally left in place for the season and then moved to another tube or site as required. Sensors are positioned on the probes to provide readings at specific depths. Measurements from the sensors are relayed at regular intervals via a cable to a data logger where it is recorded. The data from the logger is downloaded to a computer every few days to show water use and to provide recommendations for watering. Figure 4 shows the main components.



**Figure 4.** Diagrammatic representation of an Enviroscan probe

For citrus, three probes is the minimum recommendation for a block but the number of sites depends on the variability in soil and varieties. The first probe should have sensors at 10, 30, 50 and 100 cm, the second probe with sensors at 10, 30, 50, 100 and 150 cm, and the third probe with sensors at 10, 20, 30, 50, 70, 100, 150 and 200 cm.

The current cost of a logger, solar panel, 1500 m of cable, four 1.5 m probes, 16 sensors and software is about \$12 000. The equipment can also be hired from some consultants.

Because the interpretation of the data requires skill, it is recommended that consultants be used to set up the system and provide at least the initial advice.



Irrigation  
consultants  
Section 6 page 6



## Insect pest management

*Managing insect pests is probably the most difficult aspect of citrus growing. This is because there are a large number of serious pests, some will inevitably occur at some stage in the life of the crop, and many have the potential to destroy fruit yield and quality. Here are the important things you need to know:*

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The modern approach—IPM .....	50
The managed spraying alternative .....	52
Monitoring pests .....	52

### The traditional approach

---

The traditional approach to pest control was to apply routine calendar sprays of chemicals. This approach had a number of problems:

- It was a waste of money if the pests were absent.
- Even when pests were present, it disregarded the fact that trees 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 increased the risk of chemical damage to the fruit.
- It was costly with up to 30 chemical sprays being applied each season.
- It relied heavily on new chemicals being developed to replace those for which insects develop resistance. This contradicts the modern reality where fewer new chemicals are being discovered and developed.
- It was severe on beneficial insects and mites and sometimes resulted in outbreaks of pests which were normally well controlled naturally.
- It exposed the farm family and farm employees to a range of toxic chemicals.
- It increased the amount of chemical residue in both the fruit and the environment.

### The modern approach—IPM

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The modern approach to insect pest control involves less reliance on chemicals by using all or a number of complementary control measures in an integrated program known as *Integrated Pest Management (IPM)*.

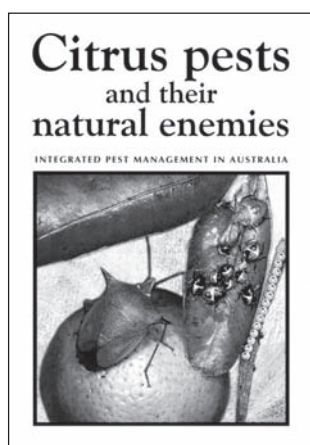
The key elements of IPM are:

- use of cultural control measures such as crop hygiene, crop rotation
- use of biological control measures such as the use of naturally occurring or introduced parasites, predators and pathogens (known as beneficials) of the insect pests
- use of chemicals only where necessary. Preference is given to chemicals which are compatible with the beneficial insects and 'softer' on the environment.
- careful application of chemicals with well calibrated spray equipment to avoid crop damage, excess residues and off-site pollution
- checking the crop regularly to determine when pests are present. Only when they are present and at damaging levels, is action taken. This process of checking the crop for pests is called monitoring. Monitoring works by first determining pest action levels - pest populations at which damage is considered worthy of attention. The action level can be thought of as the point at which the damage is roughly equivalent to the cost of control. Pest populations are then accurately monitored and control measures applied only when pest populations approach or reach this action level. Monitoring then continues to allow pest populations to be managed at or below this action level. As well as the pests, the beneficial insects and mites which naturally attack the pests are also monitored. This is done because in some cases, they alone will be sufficient to keep the pest populations in check. Monitoring requires skill in observing and identifying pests and beneficials. This requires considerable training and experience. For this reason, the use of professional pest monitoring services is recommended.

more info



Pest consultants  
Section 4 page 4



Use this book for more detail on IPM.  
See Section 6 page 13

An IPM system which uses all of the above elements is now well established in citrus. In some situations, pests such as red scale, mealybug and mites can be well controlled without chemicals. However, it is not without its risks. It works best in the following situations:

- dry inland areas
- where pest consultants or skilled monitors are available to do the monitoring and provide on-the-spot technical advice
- where you as a grower are dedicated to IPM ideals and prepared to accept the odd failure inherent in a biological system, trading that off against the advantages offered
- later in the season when the supply of beneficials is better and conditions suit their rapid buildup.

For more detail on IPM including detailed monitoring and full details of all pests and beneficials, you are referred to the book *Citrus pests and their natural enemies: integrated pest management in Australia*.

## The managed spraying alternative

If you are unable to employ the complete IPM system, you can still take advantage of the principal benefit offered—reduced chemical spraying, by using just some of the elements. This system uses the following strategy:

- monitoring pest populations broadly as outlined above
- using chemicals alone when action levels are reached
- giving preference to chemicals which are ‘softer’ on naturally occurring beneficials so that they can exercise maximum benefit
- carefully applying chemicals with well calibrated spray equipment so that maximum impact is achieved with each spray.

This strategy is called *managed spraying* and is the minimalist position we recommend for pest control in citrus.

## Monitoring pests

Whether you are using IPM or managed spraying, pest monitoring is the basic common requirement. As mentioned earlier, the use of professional pest monitoring services is recommended. These consultants visit the orchard about every ten to fourteen days between October and April to monitor pest populations. After each visit, the pest consultant provides a report on pest status, and required sprays. The cost of using a pest consultant varies depending on planting density, pest and disease status of the orchard and so on.

If you wish to do the monitoring yourself, it is suggested that you first get some training from a pest consultant. The main requirements for monitoring are:

- commitment and the time to do regular monitoring at least every fortnight
- good eyesight and a x10 hand lens, magnifying glass or small microscope
- a good knowledge of the pests and beneficial insects and mites
- common sense.

Monitoring is not intrinsically difficult and is really just a process of systematic observation and recording. Start monitoring in September/October, checking a random sample of trees each fortnight. A basic monitoring guide for the main pests is shown in the *Pest and disease management handy guide* in the front of the kit. The number of trees sampled depends on the size of the block but varies from 10 to 30 trees. While walking between the random sample trees, keep a close eye out for signs of pest activity on other trees. Five sampling units each of leaves and/or flowers and/or fruit need to be sampled from each random sample tree. These units are inspected for pest types and numbers and data recorded on special recording cards. These are then compared with the action levels to determine whether treatment is



Pest consultants  
Section 6 page 4

necessary. Action levels for the main pests are shown in Table 1. Pest levels below the action level are not considered damaging enough to warrant the cost of treatment. Pest levels above the action level mean that some action should be taken immediately to prevent further pest buildup. The most appropriate treatments are detailed in the *Problem solver handy guide* in the front of the kit.

**Table 1.** Action levels for the main pests

<b>Pest</b>	<b>Action level</b>
Brown citrus rust mite	10% or more of fruit infested
Citrus rust mite	5-10% of fruit infested
Citrus bud mite	10% or more of leaf buds infested
Broad mite	5% or more of fruit infested
Soft scales	5% or more of leaves or green twigs infested
Red scale	5% of twigs infested; 10% (early) to 20% (late) of fruit infested
White louse scale	scale evident on trunk and main limbs
Mealybug	10% of Navel or grapefruit fruit infested; 20% in other varieties
Aphids	25% or more of leaf flushes infested
Flatids	20% or more of green twigs infested
Jassids	20% or more of leaf flushes infested; 5% or more fruit infested
Spined citrus bug	10% of trees infested with one or more bugs
Leafminer	10% of advanced flushes infested (oil sprays) to 50% of advanced flushes infested (chemical sprays)
Fruit piercing moth	5% or more fruit affected
Branch borer	first sign of branch wilting
Fig and speckled longicorn borers	2 or 3 or more affected patches on trunk
Katydid	5% or more of fruit damaged
Queensland fruit fly	any observed fly activity
Gall wasp	33% or more branches infested with galls exceeding 50 mm in length
Scirtothrips	5% or more fruit infested (10% after April)



## Pruning

*Tree pruning is an important, but often overlooked, crop management operation in citrus. This is because it plays a major role in determining production and fruit quality. It is also the management operation that is most vigorously debated by growers, with many different opinions. There is no one correct system, but here are our thoughts on what should be done.*

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Pruning non-bearing trees (first four years) .....	55
Two types of pruning in bearing trees .....	55
Pruning to enhance fruiting .....	55
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### **The need for pruning**

There are a number of important reasons for pruning citrus trees:

- to allow sunlight to reach inside the tree to encourage new growth and flowering there. Remember that flowering only occurs on active growth from the previous spring. An unpruned tree with a dense leaf canopy results in flowering and fruit production being confined to the outer perimeter of the tree, thereby reducing production.
- to remove deadwood which not only marks developing fruit but also harbours pests and diseases. Deadwood occurs when growth extension shades previous growth until it becomes unthrifty and dies.
- to open up the dense outer canopy so that it is easier to harvest the fruit and achieve good spray penetration. The latter is vital for the control of pests such as white louse scale which is generally confined to the trunk and branches.
- to reduce the overcropping problem of some varieties and the need for subsequent fruit thinning. Pruned trees do not set as much fruit, reducing the need for as much fruit thinning.
- to maintain the height of trees at a level which makes harvesting and spraying easier, and which ensures light penetrates to adjacent rows.
- to allow unhindered access between the rows of trees for spraying, harvesting and other orchard machinery.

## **Pruning non-bearing trees (first four years)**

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Minimise pruning of young trees as removal of foliage delays growth and development of fruit bearing capacity. The desired structure of young trees is an arrangement of three or four well-spaced main limbs 45 to 60 cm from the ground. Most young trees develop naturally into this shape and therefore require no pruning. The only pruning that should be done during the first three years is the removal of badly crossed branches (branches growing from one side to the other), and unwanted shoots from the lower trunk. Also shorten or remove vigorous water shoots from the centre of the tree. In vigorous varieties such as lemons and Glen, Hickson, Imperial and Murcott mandarins, shorten long whippy shoots in winter to a third of their length.

## **Two types of pruning in bearing trees**

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There are essentially two different types of pruning operations in bearing trees:

- detailed individual tree pruning to enhance the fruiting capacity of each tree. This is recommended for all citrus varieties but is absolutely essential for mandarins (particularly Imperial, Glen and Murcott) and lemons.
- broadscale hedging and topping of tree rows to improve access and efficiency of harvesting and spraying operations. This is recommended for all varieties of citrus but the intensity of hedging and topping will depend on the row spacing of the trees.

## **Pruning to enhance fruiting**

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### **When and how often**

Start pruning when trees are about four to six years of age and a height of about 2.5 metres. Then prune every year or every second year depending on variety, tree vigour and severity of pruning. Pruning may be done at any time during the year but the period between harvest and the spring flush is preferred.

### **Procedure**

Follow this procedure:

1. Remove any deadwood.
2. Remove any growth within 30 cm of the ground (referred to as 'skirting'). This improves fertilising, irrigation, weed control and monitoring of thinning.
3. Selectively cut out branches from within the canopy to open it up and allow more light to penetrate. For Imperial mandarins, which require the heaviest pruning, remove enough foliage so that you can see through the tree. This generally means removing a number



of smaller branches every one or two years. A comparison of unpruned and correctly pruned Imperial trees is shown in Figures 1 and 2. Other varieties require less severe pruning but the aim should still be to remove one or two major branches every second year or so. One option is to remove one whole scaffold limb at each pruning (referred to as 'chunk' pruning). This creates a hole in one side of the tree which with progressive 'chunks' on the other sides, has the effect of progressively stimulating fruiting wood around the tree. It is recommended that 'chunks' be removed from the opposite sides of alternate trees.

4. Every now and then, cut back long fruiting arms to a point closer to the main scaffold branches (referred to as 'undercutting').



**Figure 1.** *Unpruned Imperial trees*



**Figure 2.** *Correctly pruned Imperial trees*

Throw all prunings into the interrow space for subsequent mulching with heavy mowers. The completed pruning job is shown in Figure 3.



*Figure 3. A pruned Imperial orchard*

## Hedging and topping

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### When and how often

In mature orchards, hedging or trimming back the sides of trees is necessary to maintain access for spraying and harvesting. Commence this as soon as access begins to be impeded. If this is left too late, the first hedging cuts back into major wood and may reduce the next crop. Trim as required to maintain access. In high density orchards, this will be required each year. Trim only one side of a row each year.

Topping (cutting the top of the trees) is also required when trees reach a height of about 4 to 4.5 metres. Topping then needs to be done almost every year to allow efficient pest management, easier harvesting and light penetration to the next row.

The best time to do hedging and topping is after harvest and before the spring flush.

### Procedure

Hedging and topping are generally done by specialised machines as illustrated in Figure 4. The machinery is expensive and most orchardists hire a contractor. The shape desired from hedging and topping is shown in Figure 5. The angle of hedging is about 15 degrees. Trees are topped to a height of 4 to 4.5 metres. Place all prunings in the interrow space for mulching with heavy mowers.

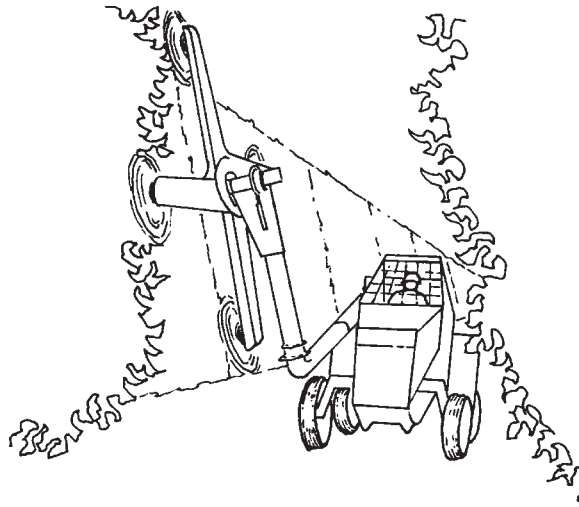
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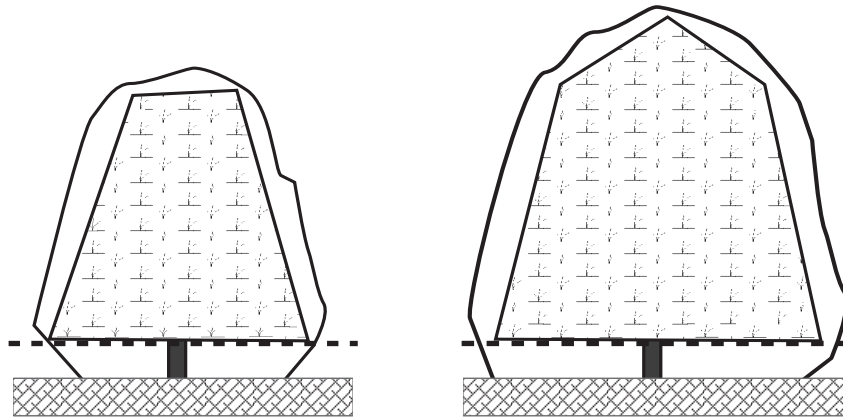
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Hedging  
contractors  
Section 6 page 6

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**Figure 4.** A modern hedging and topping machine.



**Figure 5.** Desired tree shapes after hedging and topping. Left: younger trees up to about eight years. Right: mature trees. Note that the angle of hedging is about 15 degrees.



## Fruit thinning

*As most of the mandarin varieties grown in Queensland set and try to carry excessively heavy crops, fruit thinning is a vital management operation. Tree health, fruit size and potential returns all depend on how well this operation is handled. Here are the important things you need to know.*

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Thinning methods .....	60
Understanding thinning in mandarins .....	60
Mandarin thinning.....	61
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### **The need for fruit thinning**

Under Queensland conditions, most mandarin varieties set excessively heavy crops. This has two important effects:

- fruit size is reduced by the competition between fruitlets for water and nutrients. As fruit size is a major determinant of market price, fruit must be thinned to maximise returns.
- tree health can be damaged by the huge demand placed on the tree by the large crop of developing fruit. This can be so severe in varieties such as Murcott that tree death can occur. It may also push trees into a biennial bearing pattern, significantly reducing the next crop. Thinning is essential to avoid prolonged losses in tree productivity.

Valencia oranges for the export market also require thinning to improve fruit size.

### **Varieties requiring thinning**

Not all varieties require thinning. Some such as Ellendale shed enough fruit naturally to produce a crop which is manageable for the tree. Thinning requirements are summarised in Table 1.

**Table 1.** Varieties requiring thinning

Type	Variety	Thinning required?	Comments
Oranges	Navel	No	
	Joppa	Export only	
	Valencia	Export only	Japanese market
Mandarins	Imperial	Yes	
	Glen	Yes	
	Hickson	Sometimes	Measure crop load
	Murcott	Yes	
	Emperor	No	Brown spot disease thins naturally
	Ellendale	No	
	Fremont	Yes	
	Ellenor	No	
	Nova	No	
	Sunburst	No	
	Marisol	Unknown but probably	
de Nules	Unknown but probably		
Success	Unknown		
Lemons	All varieties	No	
Grapefruit	All varieties	No	
Limes	All varieties	No	

## Thinning methods

There are two thinning methods:

- hand thinning. This is the traditional and most accurate method but is very expensive in labour terms.
- chemical thinning with ethephon (Ethrel, Bounty, Promote). This is an effective and inexpensive treatment but timing and application need to be extremely accurate to achieve effective results.

In mandarins except Fremont, a combination of the two is recommended. Chemical thinning is done first and then remaining fruit hand thinned where required. As chemical thinning rates have not yet been established for Fremont, thin this variety by hand only. No hand thinning is used in oranges.

## Understanding thinning in mandarins

Chemical thinning with ethephon works by simulating the natural involvement of ethylene in developing the abscission (or fall) layer on the stems of developing fruitlets. As ethephon breaks down to ethylene, the natural ethylene levels are increased and this accentuates the development of abscission layers.

There are two important elements of fruit thinning in mandarins:

- determining whether thinning is required. This involves measuring the density of crop on the tree to assess whether fruit numbers are sufficient to justify thinning treatments.

- where thinning is required, determining exactly when to apply the ethephon chemical treatment. If chemical is applied too early before you know how much natural fall is going to occur, excessive loss of fruit may result. If it is applied too late, the treatment is ineffective. Fruit fall in mandarins goes through a number of different natural fruit fall stages. The critical one for the treatment is the last of these natural stages when falling fruit average about 12 mm in diameter. This stage can last for only four or five days and is very easy to miss. It also varies from year to year depending on the season. As a result, falling fruit needs to be monitored every day or second day throughout this period to accurately identify the correct stage to apply the thinning chemical.

Thinning is a process that requires considerable experience and few will get it right the first time.

## **Mandarin thinning**

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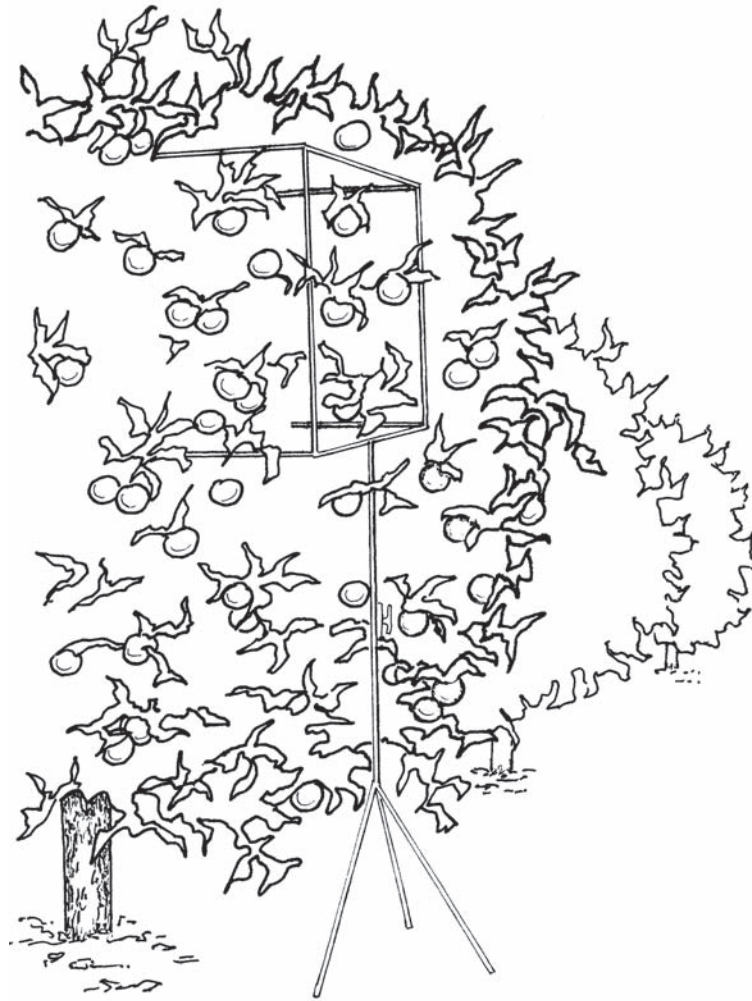
### **Determining whether thinning is required**

As it is difficult to estimate the crop load by eye when fruit is very small, an objective way of determining the need for thinning is to count the fruit in a relatively small defined volume of the tree canopy. The volume is defined by a metal framework in the form of a cube, called a quadrat, with sides 0.5 metres long (Figure 1).

The framework can be constructed from fencing wire by making a 0.5 m sided square with prongs on the corners 0.5 m long. The frame is then mounted on tripod legs with a height adjustment.

In mid October, select at least 20 healthy trees at random through a block for measurement. Place the quadrat in the tree with its prongs pointing towards the trunk with the outer edge of the quadrat at the edge of the canopy (Figure 1). Count all fruitlets inside the cube. Do one measurement per tree.

A count of 10 to 15 fruitlets per cube is about ideal. Thinning is required where there is an average of more than 15 fruitlets per cube.



**Figure 1.** *Quadrat cube for measuring crop density*

### **Determining when to apply thinning chemical (all varieties except Fremont)**

Follow this process:

1. Select five healthy trees per block of about 1000 trees to sample. Make sure the sample trees are not on the outside of the block or on the ends of rows.
2. Start monitoring natural fruit fall in early October (north Queensland) and mid October (south Queensland). Do this by either placing a 50 cm square tray or a similar sized tarp under the trees to collect the falling fruit. Alternatively, mark a similar area and sweep it clean of fruit.
3. At least every two days, measure the fruit that has fallen with a set of vernier calipers.
4. When the fruit is still falling and the average size is 12 mm in diameter, it is time to apply the thinning chemical. An equivalent measure is when approximately 20% of fallen fruit has a diameter of between 8 and 15 mm. Where fruit is not at this stage, empty out the tray, or re-sweep the area for the next recording in one or two days time.

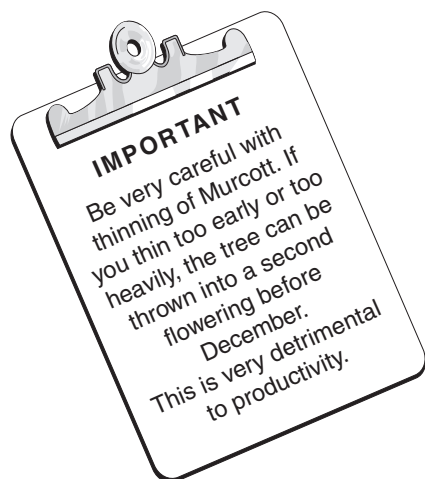


5. Immediately the right conditions are met, spray the trees with ethephon (Ethrel, Bounty, Promote) at a rate of 50 mL/100 L water (60 mL/100 L for Murcott). Ensure enough spray is applied to wet the fruitlets without runoff. This generally requires 3000 L per hectare on younger bearing trees up to about 6000 L per hectare on large mature trees. In preparation for spraying, make sure that trees are not under stress and are well watered during the period of monitoring. Stress increases fruit fall and makes the thinning operation harder to manage.
6. The accelerated fruit fall takes up to five days to start and then lasts for a few days. Don't worry if larger fruit also falls—the remaining fruit should compensate in time. Depending on the season and location, thinning sprays would normally be applied before the end of November.

### Hand thinning

Use the quadrat to again count crop load in December. If it is still more than 15 fruit per cube, hand thin fruit as soon as possible. A count of 10 to 15 fruit per cube is ideal. Hand thin to these specifications:

- Thin clusters to one or two fruit
- Have no fruit touching
- Have fruit at least 20 to 23 cm apart (about the span of a spread adult hand from the tip of the thumb to the tip of the little finger)
- Remove all small or marked fruit and fruit hanging close to the ground
- Leave terminal fruit in Imperial and Glen
- Note special Murcott provision below.



Because Murcott fruit can suffer badly from sunburn in January/February, a different thinning strategy is employed for this variety. This involves leaving extra fruit on the tree in December to allow for the removal of sunburnt fruit after the hazardous period (up to March). Alternatively, where good pruning systems have developed fruiting wood inside the canopy, fruit can be removed from the outside or at least the northern and western faces in December to effectively conclude the thinning process.

### Thinning Valencia oranges

Neither the crop load nor the fruit drop are generally monitored in this case. Instead, a thinning spray with ethephon is simply applied when the fruit on the tree averages about 15 mm in diameter. No subsequent hand thinning is employed.





## Marketing

*Marketing is one of the vital issues in successful citrus growing but regrettably one which is often seen to be secondary to the issues related to growing the crop. But marketing is probably the issue that will make the biggest difference to your success as a grower. There is no doubt that the future market for citrus will continue to become tighter and more competitive. To maintain a profitable margin, growers will need to be more involved in marketing. This section covers the main things you need to know. Most of the information relates to marketing fruit domestically in the main metropolitan wholesale markets as that is where most Queensland fruit is marketed.*

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Know what the market wants .....	65
Deliver the product that the market wants .....	65
New and improved market opportunities .....	68
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### **The essentials of marketing**

Whatever market you intend to target, there are three essentials:

- you must know what the market wants. Customers are becoming more demanding, particularly in the areas of food safety and quality, and are better communicating their needs to marketers. You need to be in touch with these needs. The old adage—‘grow for the market—not market what you grow’, is a good concept to work under.
- you must gear your production and marketing system to deliver a product that meets those market needs. Quality management is considered the only way of consistently ensuring your product meets these market needs.
- you must be prepared to get involved in researching the market for new and improved opportunities. This is vital if prices and returns are to be maintained over a long period in an increasingly competitive environment.

more info



Market information  
Section 6  
pages 14-20

more info



Export organisations  
Section 6 page 8, 9

## Know what the market wants

There are two important sources of knowledge and information on market wants:

- market research studies. These are generally conducted by industry and research organisations and are published in special reports. Grower organisations, the Australian Horticultural Corporation (AHC) and the Horticultural Research and Development Corporation (HRDC) are sources of this information.
- marketers who are in close contact with buyers and consumers. For the domestic market, specialist citrus wholesale agents in the major metropolitan markets are an invaluable source of detailed market knowledge. Market authorities in each of the major markets can provide some advice on specialist citrus wholesalers. For the export market, citrus exporters and citrus export organisations are an equivalent source of expert market knowledge.

Check out these sources for detailed information. In general, consumers are looking for brightly coloured, juicy fruit of reasonable size, with smooth, thin skins. Additional features sought in mandarins and oranges are sweetness and ease of peeling. There is an increasing demand for seedless varieties but at this stage it is not a significant factor in consumer purchase. In addition, varieties that have a well established reputation with consumers are generally better accepted than new unknown varieties.

Remember that quality is invariably more important than price as a factor in consumer purchase.

## Deliver the product that the market wants

Having established what the market wants, the next step is to gear your production and marketing system to deliver a product with those specifications. The only way of ensuring this is to have a quality management system at the farm level. Becoming part of one of the marketing groups or cooperatives that have quality management systems is the easiest way of doing this. However, if you are not part of a group quality system, you can implement your own quality management system.



## Understanding quality management

Quality is a term used to describe the fitness for purpose of a product. It implies a predictable degree of uniformity and dependability. Quality management is the control exercised over all of the activities that influence product quality.

In the past, the suitability of the product for its intended market was determined by what is called 'end point inspection'—inspection at the market level. This system has a number of important flaws:

- it is expensive to reject product at this late point in its cycle
- it is difficult to predict product performance during the rest of the marketing process when its past history is unknown
- it is often driven more by tradition than by real market needs.

Modern quality management aims to build quality right through the production and marketing process so that there is little or no need for rejections late in the piece. This system also provides consumers with documented evidence that the product they are buying will meet their needs. As such, quality management is a marketing tool to achieve better prices and repeat sales, as well as a productivity improvement tool to identify problem areas, prevent mistakes and reduce wastage.

Remember that the core principles of quality management are:

- it is the customer who defines quality, not you
- decisions are based on facts, not feelings
- problems are identified at the earliest possible point, not at the end point
- it has to be planned, organised and managed—it does not happen by itself
- it is the responsibility of everyone in the business including the workers—it is not just the responsibility of management.

### Implementing a quality management system

Here is the broad process you need to follow:

- First learn about quality management. Read as much as you can about the subject and attend training courses where these are available. The Australian Horticultural Corporation has some excellent information and training resources on the subject.
- Develop a plan which sets out the standards you want to achieve.
- Share your plan with any staff (managers, pickers, packers) and ask for feedback. Involve staff at all stages from here on.
- Critically analyse your current system for its strengths and weaknesses in meeting the standards. This may involve preparing a flow chart of operations, a hazard analysis and an organisational chart.
- Develop new or modified operations to provide the quality standards you are seeking. These could involve field operations such as selection of varieties, management of nutrition, watering, pest and disease control, picking etc., as well as packing, handling and refrigeration operations after harvest. Document this in a quality management manual.
- Train your staff in the quality system and make your quality standards clearly visible to all by displaying them on posters.




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Information on  
quality  
Section 6 page 16

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Details of *Citrus Growing Manual* Section 6 page 15

- Set up a recording system to carefully record and document all operations so you can see exactly what you have done should problems arise. A complete quality recording and documentation system for citrus is contained in the *Citrus Growing Manual* produced by Greg Moulds on behalf of HRDC. A sample of the recording sheets is shown in Figure 1.

ANNUAL CITRUS NUTRITION PROGRAM 19...		LEAF LEVELS			PREVIOUS YEAR FERTILISER										
UNIT INFORMATION		CROP INFORMATION			FERTILISER PROGRAM FOR THE COMING YEAR										
Name:	Yield (t/Ha)	N	%	%	Nitrogen	kg/Ha									
Address:	Sugar/acid ratio	P	%	%	Phosphorus	kg/Ha									
Unit:	Fruit size/texture	K	mg/kg	mg/kg	Potassium	kg/Ha									
Farm:	TSS	Zn	mg/kg	mg/kg	Zinc	mg/kg									
Variety:	Packout	Mn	mg/kg		Manganese	mg/kg									
Rootstock:		Other critical			Other critical										
Rates (kgs element/Ha)		Fertiliser type (kgs fert/Ha)		Month of year											
N	kg/Ha	kg/Ha	kg/Ha	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
P	kg/Ha	kg/Ha	kg/Ha												
K	gm/100L	gm/100L	gm/100L												
Zn	gm/100L	gm/100L	gm/100L												
Mn	gm/100L	gm/100L	gm/100L												
Cu	gm/100L	gm/100L	gm/100L												
Mg	gm/100L	gm/100L	gm/100L												
Other	gm/100L	gm/100L	gm/100L												

Citrus growing manual Management records

Figure 1. Sample of one of the recording sheets

- Appoint a quality auditor (or be that person yourself) to audit your quality management system and make sure it is working. This can be done by randomly selecting for inspection a sample of each grade of each consignment. About one carton in every 25 needs to be inspected. Check this sample of fruit for all facets of quality. Record these objective assessments. Keep a sample of fruit aside in the cool room so you can check its marketing characteristics in a few days time when your consignment will be in the hands of the retailer and consumer. Also ask your wholesale agent to provide feedback on the quality of your fruit.

Remember that it is not easy to put a quality management system together. You will need commitment, good planning, staff involvement, and simple and effective procedures including well defined and objective quality standards.

## **New and improved market opportunities**

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Having developed a system to provide a product that meets the market need, it is important that you do not rest on your laurels. To maintain a competitive advantage, it is necessary to maintain an active involvement in researching new and improved market opportunities. Here are some of the things that can be done:

- Consider getting together with other growers to develop group cooperative marketing under a common quality management system. Through the longer lines of consistent quality produced under this system, access is possible to market segments unavailable to most individual growers.
- Groups should consider using a professional marketing coordinator, particularly for export markets. A coordinator maintains close contact with all of the markets throughout Australia and overseas. The product can then be directed to each market based on the coordinator's intimate knowledge of how much it can handle before it is oversupplied and prices fall. The coordinator may also undertake market development and promotion on behalf of the group. By the coordinator handling all of the marketing decisions and problems, growers are allowed to concentrate on the task of growing quality fruit.
- Consider any value adding opportunities. Remember that consumers now are better educated, more health conscious, and are demanding more convenience in their foods.
- Support any market research proposed by your industry as it will greatly benefit your future marketing opportunities.
- Support any promotional activities implemented by your industry, including those aimed at improving fruit handling in the wholesale and retail markets. These will increase sales and potential returns.
- Look for specialist citrus wholesalers who present a positive enthusiastic impression particularly when things are tough. Wholesalers who specialise in seven or eight products normally develop more expertise in the product and should do a better marketing job than generalists.

## **Export**

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Exporting of mandarins and oranges is well established, although this currently accounts for only 10 to 15% of total production. Export destinations include Canada, Indonesia, Hong Kong, Malaysia, Singapore, Japan, the Middle East and Europe. Export has complex and specialised requirements and is normally only available to large growers or marketing groups or cooperatives. It requires strict attention to quality standards and quarantine requirements. For example, the Japanese market has a nil tolerance for black spot and fruit fly. Fruit must be subjected to a cold disinfestation treatment, which demands

that fruit be kept at 0°C for 16 days. A Japanese inspector must be present for this procedure and the stuffing of the shipping container. Growers pay all costs.

Queensland has a number of strengths in the continuing development of exports. It is close to the growing Asian markets, its skill base enables good quality fruit with a clean, green image to be produced, its production is counter seasonal to most northern hemisphere producers, and it is growing varieties such as mandarins with a significant export demand. As a result, potential for export growth is sound. However, remember that each export market has different fruit preferences, different quality requirements and different quarantine and disinfestation treatments.

Seek the advice of exporters and citrus exporting organisations before proceeding.

more info



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