Tomato information kit

Reprint – information current in 1998

REPRINT INFORMATION – PLEASE READ!

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

This publication has been reprinted as a digital book without any changes to the content published in 1998. We advise readers to take particular note of the areas most likely to be out-of-date and so requiring further research:

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- Financial information—costs and returns listed in this publication are out of date.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

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

This publication was last revised in 1998. 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 tomatoes. This information is not to be used or relied upon by users for any purpose which may expose the user or any other person to loss or damage. Users should conduct their own inquiries and rely on their own independent professional advice.

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

Queensland Government

Key ISSUES

Key issues supplements our growing and marketing recipe in Section 3. 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 understood. Where additional information may be useful, we refer you to other parts of the kit. Symbols on the left of the page will help you make these links.

continued —

Understanding the tomato plant

Tomatoes are one of the most commonly used vegetables in Australia, although botanically they are a fruit. They are high in vitamins A and C, with 100 g containing 20% and 40% of the recommended daily allowance of vitamins A and C respectively.

Plant types

Tomato plant type is usually expressed in terms of whether the plants are determinate or indeterminate and whether the fruit stalks are jointed or jointless.

A **determinate** tomato variety grows a bush to no more than about 1 m high then stops growing, having set a concentrated crop. Determinate varieties are ideally suited to a ground cropping system where the bulk of the crop is picked in a few harvests. Most processing varieties grown for once-over harvest are determinate types. Pruning determinate varieties will greatly reduce yields.

An **indeterminate** tomato variety never stops growing, reaching a height (length) of over 5 m when fully mature, and can be harvested over 12 to 20 weeks. Indeterminate varieties are more suited to glasshouse than field production, though many cherry tomato varieties are indeterminate types. Indeterminate tomatoes need to be trellised or staked and are usually pruned to increase the size of the fruit. Most gourmet varieties have an indeterminate growth habit.

Semi-determinate varieties usually grow to 1.5 to 2 m high and set fruit over a longer period than determinates. They are well suited to trellis or ground cropping systems and are harvested over two to six weeks. Semi-determinate varieties are generally not pruned as pruning reduces yields.

A **jointed** tomato variety is one where the fruit stem and calyx remain attached to the fruit when harvested. There is a joint or knuckle on the fruit stem that breaks when the fruit is pulled off the bush. Figure 1 is a diagram of jointed and jointless fruit.

Jointless varieties do not have this joint or knuckle and the fruit detach from the bush with no fruit stem and calyx attached. Most growers prefer to grow a jointless variety. Few fruit are marketed with the fruit stem and calyx still attached. The exceptions are some specialty varieties that are usually grown hydroponically under cover and the stalk is left on as an indication of freshness. The fruit are usually packed in single layer trays to prevent damage from the stalks.

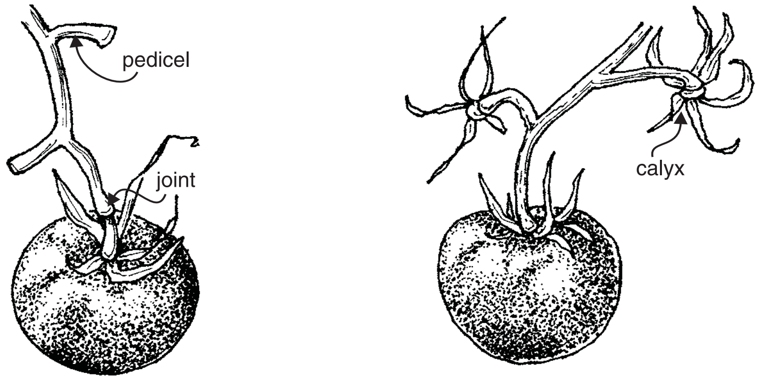


Figure 1. *A diagram of jointed (left) and jointless fruit*

Effect of temperature

Tomatoes are sensitive to temperature, the degree of sensitivity varying with the growth stage of the crop. Sudden cold snaps can cause severe fruit cracking. Tomatoes are also susceptible to frost damage at all stages of growth.

The optimum range for germination is between 20 and 30°C, but decreases rapidly below 15°C and is reduced above 35°C. Tomato seeds do not require vernalisation. Vegetative growth from field planting to flowering can be excessive during summer and early autumn. During these times temperatures ranging from 26 to 30°C daily maximum and 17 to 23°C night minimum are typical. Vegetative growth is minimal above 35°C.

Varieties vary in their sensitivity to temperature and this will influence pollination and fruit set. Under marginal conditions fruit may set without adequate pollination but the internal fruit segments will contain few seeds and the tomato will be flat-sided and puffy. Irregular pollination can also cause the fruit disorder known as catface. Fruit setting is reduced when temperatures fall below 10°C or rise above 27°C. Optimum temperature for fruit set is 18 to 24°C. Major reductions in fruit set will occur when the minimum night temperature is more than 22°C. Daily maximums below 18°C will also reduce fruit set.

Temperature during the fruit development stage is less critical, but if the temperature exceeds 28°C the fruit may be softer than fruit maturing under cooler conditions.

Temperatures above 22°C may cause fruit to ripen orange or yellow, particularly if leaf cover is poor and fruit is exposed directly to sunlight.

Production times are mainly based on climatic conditions. Table 1 shows the main planting and harvesting time for the major production areas of Queensland.

Table 1. *Main planting and harvesting times of tomatoes for the major districts*

District	Plant	Harvest
North Queensland	February – early September	April – early December
Bundaberg	mid January – mid April mid July – mid September	mid April – mid August October – early January
South-east Queensland	late August – February	November – May
Granite Belt	October – December	January – April

Crop cycle

Tomatoes go through a vegetative stage of growth before setting fruit. If growth is poor during this stage the plant will be small, which reduces its ability to carry and fill out many fruit and also increases the risk of fruit damage because of poor leaf coverage. Fruit setting occurs when there is moderate vegetative growth and the balance between nitrogen and carbohydrates is correct. Over vigorous growth is usually due to excess nitrogen and results in soft plants that will not set early fruit, even though they flower, because their carbohydrate levels are too low.

To set fruit tomato plants must accumulate a surplus of carbohydrates well above what they need for vegetative growth. The fruit cells continue to divide for two to three weeks after setting and all fruit growth after this is the result of the fruit cells expanding. In normal varieties pink colouring at the blossom end of the fruit indicates growth is complete and ripening has begun. Research indicates that ripening starts about two days before the external colour changes. Tomatoes are climacteric fruit, that is ethylene triggers a very rapid ripening process. During ripening there is a high respiration rate releasing large amounts of carbon dioxide and ethylene. These changes affect the whole ripening process.

Table 2 shows the normal time range for each stage of plant growth. The short intervals are in the hotter weather while each stage takes longer in cool conditions.

Table 2. *Normal time range for each growth stage of the tomato plant**

Plant stage	Time
Sowing to germination	4 – 10 days
Emergence to field planting	4 – 8 weeks
Field planting to first flower	3 – 4 weeks
First flower to harvest	6 – 8 weeks
Duration of harvest*	1 – 12 weeks

*Depends whether a ground or trellis crop, or cherry tomatoes.

Economics of production

One way of assessing the economics of tomato production is by calculating the gross margin for the crop. A gross margin is the difference between the gross income and the variable or operating costs. The variable or operating costs include the growing, harvesting and marketing costs. The calculation does not consider fixed or overhead costs such as rates, capital, interest, electricity, insurance and living costs. These fixed or overhead costs must be taken into account in calculating a whole farm budget.

All data included in this gross margin are based on information provided to the authors. No responsibility can be taken for its accuracy. This data should be confirmed and changed where necessary by the user before any decisions based on the result are made.

The following gross margins are for normal, round tomatoes grown on a trellis at Bundaberg and as a ground crop in the dry tropics. The cost of production of gourmet types is said to be about $3 per carton higher than for round tomatoes.

Assumptions

The calculations assume container-grown seedlings are planted and grown with good management using plastic mulch and trickle irrigation. All machinery operations include costs for fuel, oil, repairs and maintenance (F.O.R.M.). No allowance is made for owner-operator labour. This gross margin template was designed for/by the Queensland Farm Financial Counselling Service.

A gross margin for south-east Queensland (Bundaberg)

Enterprise unit: 1 ha trellised tomatoes

REVENUE	Amount	$/unit	$ /carton	Total $ /ha
Price ($/carton)			$10.00	
Cartons /ha	5 000			
TOTAL REVENUE				**$50 000.00**

VARIABLE EXPENSES	/ha	$ /unit	$ /ha	Total $ /ha
Land preparation (F.O.R.M.)				
Ripping	1	$16.90 /ha	$16.90	
Cultivation	1	$7.00 /ha	$7.00	
Disc harrowing	2	$15.70 /ha	$31.40	
Rotary hoeing	1	$19.40 /ha	$19.40	
Bedding — forming	1	$34.00 /ha	$34.00	
TOTAL LAND PREPARATION EXPENSES				**$108.70**
Planting				
Seedlings (each)	11 110	$0.055	$611.05	
Transplanter ($ /ha)	1	$27.40 /ha	$27.40	
Casual labour	24 hours	$9.98 /hr	$239.52	
TOTAL PLANTING EXPENSES				**$877.97**
Trellising				
Construction and dismantling — per crop				
Casual labour		$9.98	$1 646.70	
Tractor only	165 hours	$1.40	$21.00	
Materials — assume a life of 8 crops				
Timber posts	70 ha	$10.00 /post	$87.50	
Wooden stakes	1 365 ha	$1.00 /stake	$170.63	
Wire	44 500 m/ha	$0.04 m	$222.50	
Ties	4 095 /ha	$0.03 each	$122.85	
TOTAL TRELLISING EXPENSES				**$2 271.18**
Fertiliser				
Ag-Lime (spread)	5 t	$49.50 /t	$247.50	
Crop King 55	400 kg	$0.50 /kg	$201.00	
Potassium nitrate	8 x 25 kg	$0.88 /kg	$176.00	
Calcium nitrate	4 x 20 kg	$0.65 /kg	$52.00	
Spreader	1	$5.00 /ha	$5.00	
TOTAL FERTILISER EXPENSES				**$434.00**
Plastic mulch				
Plastic mulch (black)	5 556 m	$0.09	$500.04	
Casual labour	8 hours	$9.98	$79.84	
TOTAL PLASTIC MULCH EXPENSES				**$579.88**
Weed control				
Spray.Seed 250	2 x 2.8 L	$10.00 /L	$56.00	
Sprayer ($ /ha)	2	$3.00	$6.00	
TOTAL WEED CONTROL EXPENSES				**$62.00**
Insect control (Applied with fungicides)				
Lannate	12 x 1.5 L	$11.80 /L	$212.40	
Thiodan	6 x 2.1 L	$7.50 /L	$94.50	
Dipel Forte	12 x 1 kg	$62.00 /L	$744.00	
Nitofol	6 x 1.9 L	$38.60 /L	$440.04	
Dimethoate	6 x 0.75 L	$8.70 /ha	$39.15	
Vertimec	2 x 0.4 L	$210.00 /ha	$168.00	
TOTAL INSECT CONTROL EXPENSES				**$1 698.09**

VARIABLE EXPENSES	/ha	$ /unit	$ /ha	Total $ /ha
Disease control				
Dithane	15 x 2 kg	$6.75 /kg	$202.50	
Copper hydroxide	15 x 2 kg	$8.33	$250.00	
Benlate	2 x 1 kg	$48.80 /kg	$97.60	
Bravo	6 x 3 L	$12.35 /L	$222.30	
Rovral Aquaflo	2 x 1 L	$73.60 /L	$147.20	
Rugby	100 kg	$8.67 /kg	$866.67	
Sprayer ($ /ha)	23	$3.00 /ha	$69.00	
TOTAL DISEASE CONTROL EXPENSES				**$1 855.27**
Irrigation				
Water charges	4 ML /ha	$37.20 /ML	$148.80	
Electricity — single pumped	4 ML /ha	$20.80 /ML	$83.20	
T Tape medium weight	5 556 m/ha	$0.10 /m	$555.60	
Assume a 10-use life:				
Layflat 3" hose	200 m/ha	0.1 x $2.22 /m	$44.40	
Layflat to T Tape fitting	35 /ha	0.1 x $1.15 each	$4.03	
Flushing valves	35 /ha	0.1 x $1.39 each	$4.87	
TOTAL IRRIGATION EXPENSES				**$840.89**
TOTAL GROWING EXPENSES			**$1.75 /ctn**	**$8 727.98**

HARVESTING AND PACKAGING		Cost	$/carton	$/ha
Cartons				
Tomato cartons (18 L)	5 000	$1.16	$1.16	$5 800.00
Harvesting and packing				
Labour: picking	16 ctn /hr	$9.98	$0.62	
Labour: packing	12 ctn /hr	$9.98	$0.83	
Labour: sorting	50 ctn /hr	$9.98	$0.20	
Labour: grading	50 ctn /hr	$9.98	$0.20	
Pre-cooling		$0.25 /ctn	$0.25	
Total harvesting expenses	5 000 ctns		$2.10	$10 500.00
TOTAL HARVESTING AND PACKING EXPENSES			**$3.26**	**$16 300.00**
MARKETING				
Freight (to Sydney)			$1.37	
Commission, levies	12.5%		$1.25	
Total marketing expenses	**5 000 ctns**		**$2.62**	**$13 100.00**
TOTAL VARIABLE EXPENSES			**$7.63**	**$38 127.98**

Gross margin = Total revenue minus total variable expenses	
Total revenue	$50 000.00
Minus total variable expenses	– $38 127.98
GROSS MARGIN per HECTARE	**$11 872.02**

BREAK EVEN YIELD at $10.00 per carton	2 118 cartons per hectare
BREAK EVEN **MARKET** PRICE per carton (5 000 cartons /ha)	$7.29 per carton
BREAK EVEN **ON FARM** PRICE per carton (5 000 cartons /ha)	$5.01 per carton
GROSS MARGIN per MEGALITRE of IRRIGATION WATER	$2 968 per ML

Harvesting decision: At current price, is it worth harvesting?

On-farm price (market price less marketing costs)	$7.38
Harvesting and packing	$3.26

Therefore, it is worth harvesting.

Actual gross margin when price or yield changes

		Price per carton				
Yield	**cartons /ha**	**Low $8**	**$9**	**Medium $10**	**$11**	**High $12**
Low	4 000	$752	$4 232	$7 752	$11 232	$14 752
	4 500	$1 937	$5 852	$9 812	$13 727	$17 687
Medium	5 000	$3 122	$7 472	$11 872	$16 222	$20 622
	5 500	$4 307	$9 092	$13 932	$18 717	$23 557
High	6 000	$5 492	$10 712	$15 992	$21 212	$26 492

Enterprise characteristics	
Growing risk	Medium
Price fluctuations	Medium
Working capital requirement	High
Harvest timeliness	High
Management skills	Medium
Quality premium	Yes
Spray requirements	High
Labour requirements — growing	Medium
Labour requirements — harvesting	High

Last update: March 1998

A gross margin for north Queensland (Bowen)

GROSS INCOME	**Yield (10 kg cartons /ha)**	**Price per carton**	**$ /ha**
	3 000	$10	30 000

PREHARVEST COSTS	**Operations**	**$ /operation**		**$ /carton**	**$ /ha**
Machinery costs (F.O.R.M.)					
Ripping	1	$47.47		$0.02	$47.47
Discing	2	$38.82		$0.03	$77.64
Rotary hoe	1	$16.67		$0.01	$16.67
Bed and mulch	1	$22.23		$0.01	$22.23
Planting	1	$44.47		$0.02	$44.47
Tape laying	1	$11.12		$0.00	$11.12
Inter-row herbicide	1	$11.12		$0.00	$11.12
Spray application	16	$7.78		$0.04	$124.48
Mulch removal	1	$16.37		$0.01	$16.37
Container-grown seedlings		9 000	$0.08	$0.24	$720.00
Fertiliser		**/ha**	**$/unit**	**$ /carton**	**$ /ha**
Pre-plant					
CK55		350 kg	$0.52	$0.06	$182.00
Trickle					
Urea		30 kg	$0.42	$0.00	$12.60
Potassium nitrate		80 kg	$0.81	$0.02	$64.80
Calcium nitrate		80 kg	$0.84	$0.02	$67.20
Superphosphate		200 kg	$0.35	$0.02	$70.00
Foliar					
Solubor		4 kg	$3.20	$0.00	$12.80

	Applications	/ha	$/unit	$ /carton	$ /ha
Herbicide					
Spray.Seed	1	3.5 L	$9.98	$0.01	$34.93
Insecticide					
Nitofol	7	0.5 L	$38.17	$0.04	$133.60
Helothion	7	1 L	$15.00	$0.04	$105.00
Folidol	7	0.7 L	$9.69	$0.02	$47.48
Kelthane	7	2.5 L	$13.78	$0.08	$241.15
Fungicide					
Mancozeb	12	3.5 kg	$7.05	$0.10	$296.10
Bravo	4	3 L	$14.03	$0.06	$168.36
Nematicide					
Nemacur	1	24 L	$42.65	$0.34	$1 023.60
Water charges		4 ML/ha	$3.20 /ML	$0.00	$12.80
Labour cost		50 hours	$12.50 /hr	$0.21	$625.00
Irrigation					
Trickle tape		6 600 m	$0.14 /m	$0.26	$792.00
Layflat (4", 4-year-life)		50 m	$3.40 /m	$0.06	$170.00
Plastic mulch		6 600 m	$0.07 /m	$0.15	$462.00
Crop monitoring /ha			$148.00	$0.05	$148.00
TOTAL PREHARVEST COSTS				**$1.92**	**$5 760.99**

POSTHARVEST COSTS	cartons /hr	$ /hr	$ /carton	$ /ha
Harvesting and packing				
Picking	10	$17.00	$1.70	$5 100.00
Packing	12	$12.00	$1.00	$3 000.00
Dipping			$0.02	$60.00
Pre-cooling			$0.35	$1 050.00
Cartons			$1.32	$3 960.00
Machinery costs			$0.20	$600.00
Cartage on farm			$0.15	$450.00
TOTAL POSTHARVEST COSTS			**$4.74**	**$14 220.00**

MARKETING COSTS		$ /pallet	pallets /ha	$ /carton	$ /ha
Road freight (cooled)	Brisbane	$115.00	31.25	$1.20	$3 593.75
(Pallet = 96 cartons)	Sydney	$190.00	0	$0.00	$0.00
	Melbourne	$220.00	0	$0.00	$0.00
Commission	12.5%			$1.25	$3 750.00
Levies ($0.09 /package)				$0.09	$270.00
TOTAL MARKETING COSTS				**$2.54**	**$7 613.75**

Summary table

	$ /carton	$ /ha
TOTAL PREHARVEST COSTS	$1.92	$5 761
TOTAL POSTHARVEST COSTS	$4.74	$14 220
TOTAL MARKETING COSTS	$2.54	$7 614
TOTAL VARIABLE COSTS	**$9.20**	**$27 595**

BREAK EVEN PRICE = $9.08

Gross margin = Gross income less total variable costs

	$ /carton	$ /ha
Gross income	$10.00	$30 000
Less		
Total variable costs	$9.20	$27 595
GROSS MARGIN	**$0.80**	**$2 405**

Income, costs and gross margin /ha at several prices per carton

$ /carton	Gross income	Variable costs	Gross margin
$7	$21 000	$26 470	– $5 470
$8	$24 000	$26 845	– $2 845
$9	$27 000	$27 220	– $220
$10	$30 000	$27 595	$2 405
$11	$33 000	$27 970	$5 030
$12	$36 000	$28 345	$7 655

Gross margin at different yields and prices

	Yield per hectare		
$ /carton	2 700	3 000	3 300
$7	– $5 709	– $5 470	– $5 231
$8	– $3 346	– $2 845	– $2 343
$9	– $984	– $220	$544
$10	$1 379	$2 405	$3 432
$11	$3 741	$5 030	$6 319
$12	$6 104	$7 655	$9 207

Last update: March 1998

Container-grown transplants

Container-grown transplants reduce the amount of time the crop is in the field, and so reduce the risk of losses and competition from weeds. They are, however, more expensive to grow than planting seed.

Comparison of transplants with direct seeding

These are the advantages of container-grown seedlings:

- Seedlings are raised in a sheltered environment when outside conditions are unsuitable then planted out when conditions are favourable, giving them a head start over seed planted in the soil.
- Early production can lead to better markets.
- Less water is required in establishment.
- Better weed control is possible.
- Seed costs are lower.
- More time is available for land preparation.
- There are no losses in the field from cutworm or wireworm attack.

These are the disadvantages of container-grown seedlings:

- It costs more to plant seedlings than direct seeding.
- Sunburn will cause losses if seedlings get too tall or are not hardened off properly.

Growing container-grown seedlings

Introduction

Seedlings are best grown by nurseries who have the right equipment and expertise to grow plants well because poorly grown plants have a lower yield potential than well grown, sturdy plants. However, some growers prefer to produce their own seedlings.

To grow healthy seedlings, it is essential to use an open, well drained, sterile potting mix with sufficient nutrients to give the seedlings a good start. Many different mixes have been used successfully; one mix is shown in Table 3.

Mix ingredients thoroughly, add about 5 L of water and mix again. This dampens the peat so that water penetrates the filled trays more easily. Mix ingredients for up to three minutes. Over mixing will damage the vermiculite and reduce the aeration and water-holding ability of the mix.

Ridomil 50G can be included in the mix at the rate of 2.5 g/10 L of mix to control damping-off (*Pythium* spp.).

Table 3. *A mix used for growing container-grown tomato seedlings*

Ingredient	Quantity
Peat	20 L
Vermiculite	20 L
Fine milled superphosphate	100 g
Dolomite	100 g
5:6:5 (N:P:K) fertiliser	30 g
Blood and bone	30 g
Iron sulphate	7 g
Trace elements	7 g

A wide range of trays is used but the inverted pyramid Speedling-type trays seem to give the best results. The larger the cell, the more space is available for plants and shorter, sturdier plants result. The 64-cell Speedling tray and 90-cell plastic trays are commonly used for tomatoes. If cells are too small, seedlings will be soft and lanky and more susceptible to disease.

Planting

Fill trays evenly with mix. Plant two or three seeds per cell and cover with 6 mm of mix or vermiculite. Thin to one plant per cell when two weeks old. For more expensive hybrid seed, only one seed per cell can be justified though 5 to 10% of cells will not germinate. Some nurseries manually prick out spare seedlings into these empty cells to maximise the use of nursery space and trays.

Vacuum seeders are used in most nurseries to drop one seed per cell into the trays. About 250 seedlings per gram of seed are produced using this method.

To assist uniform and rapid germination, the planted trays are often placed in a warm room on pallets. Take care to ensure that the seedling only starts to emerge from the tip of the seed before taking the trays out and placing them on racks, either outdoors or in the plant house. The racks should be at least 50 cm above ground level for drainage, air pruning of the roots and to prevent soil-borne diseases being spread by water splash from the ground. Waist-high racks are easier for staff.

Watering

Water trays once or twice daily and up to three times daily in hot weather. Water with an electrical conductivity (EC) of less than 1200 microSiemens per centimetre is essential for good vigorous seedling growth. Above this level, reduced growth and leaf burn become a problem.

Watering should be slow to completely wet the mix. Over watering is a common mistake and causes nutrient leaching and disease build-up. Sufficient water has been applied when water is first noted dripping from the bottom of the cells.

Uniformity of watering is important to ensure optimum growth of all seedlings. Wind plays havoc with the water distribution of the small sprinklers used in nurseries. Windbreaks (trees or shade cloth) are necessary to prevent poor water distribution and promote vigorous seedling growth.

Fertilising

Apply nutrients with a high nitrogen content (for example Aquasol or Thrive) as a foliar spray when plants are about one week old. Spray once or twice weekly until plants are hardened off. Potassium nitrate can also be applied at 2 g/L.

Multi-nutrient foliar applications will supply most trace elements. When seedlings are to be planted into a soil known to be low in a particular element (for example molybdenum, zinc or boron), apply special foliar sprays before transplanting.

Protecting seedlings

Hygiene is the most important consideration in protecting your seedlings. Clean mixing areas, sterilised trays, raised benches, safeguards against virus spread, and quarantine of diseased seedlings are all important nursery practices.

Spray regularly to control target spot and bacterial diseases. If necessary spray to control insect pests such as aphids, heliothis and leaf miner in seedlings.

To promote sturdy growth, grow seedlings in full sun. In extremes of weather, nursery coverings are used to protect the transplants. Plastic coverings are used in winter to warm them, however, high humidity and condensation can be a problem. Thirty-per-cent shade cloth may be used in summer to protect transplants from heat and moisture stress.

Transplanting

Seedlings are ready for transplanting into the field once they will pull cleanly out of the tray, that is when the roots have fully penetrated the mix. For cup transplanters, seedlings should be more than 12 cm tall for best results. Waterwheel planters are not affected by seedling height, but if seedlings are too small they may be trapped under the plastic in windy weather.

To harden seedlings before planting out expose them to full sunlight several days before planting. Water well immediately before and after planting out.

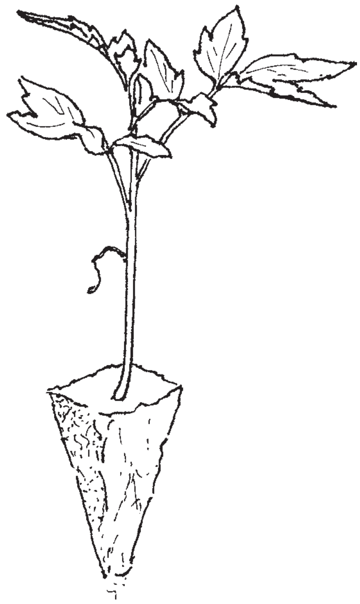


Figure 2. *A tomato seedling ready for planting*

Things to remember

When growing your own seedlings, remember:

- sterilise trays before re-use;
- do not over-compact mix in trays;
- keep potting mix moist; (Use low output sprinklers which give an even cover of all trays. Cells on the outside of trays tend to dry out faster. Water until trays start to drip.)
- drain water out of pipes before watering; (This water may be hot and scald plants.)
- keep trays level; (This prevents low spots being over watered and high spots left dry.)
- put trays on wire-based, raised benches to allow air pruning of roots; (Air pruning prevents root growth out of the bottom of trays because air dries out this growth.)
- maintain a regular spray program as conditions are ideal for disease development;
- protect plants from wind and heavy rain;
- provide warm conditions in winter.(A plastic growing house will result in better plants grown in a shorter time. In cold areas, heating will allow more accurate scheduling of seeding and planting.)

Varieties

The quality of tomato that you produce depends mainly on the variety you plant. Seed companies regularly release new varieties. A variety that performed well in one district or on another farm in your area will not necessarily perform well on your farm. We suggest that you try small areas of new varieties on your farm before making large plantings.

Select varieties

Variety selection is an important decision as there is no one variety that performs best across all planting seasons and production techniques. You need to consider fruit firmness, fruit size and shape, yield, bush size in relation to growing technique (ground or trellis), disease resistance and the climatic stresses during the production period. Concentrated setting is a desirable feature, particularly for ground crops.

Most current plant varieties have resistance to or tolerance of some diseases. Select a resistant variety if you know you have a particular disease, for example fusarium wilt race 3 or bacterial wilt.

Plant varieties for trial alongside your standard varieties so that you can assess a new variety's performance on your farm against your current varieties.

Types of tomatoes

Until recently the main type of tomato grown was the round or normal type, with smaller areas of egg or Roma types; cherry and teardrop or pear tomatoes; and small quantities of gourmet types grown under cover. There has recently been a major change to growing gourmet types under normal field conditions.

Round (normal) tomatoes

Round (normal) tomatoes have until recently been the most commonly grown tomato and are referred to in the USA as beefsteak tomatoes. They may be determinate, semi-determinate or indeterminate and grown as ground or trellis crops. The fruit are generally larger than other types because they are multi-locular, that is they have five or more locules (the portion of the fruit that contains the seed and gel (Figure 3).

Gourmet (jointed) tomatoes

Gourmet is a poor choice of words to describe this tomato type but it has become the common term. Until recently gourmet varieties were grown almost exclusively under cover in glass or plastic houses, often using a type of hydroponic culture. They all have jointed fruit stalks and are mostly indeterminate so require trellising or staking, and pruning. Plant breeders are developing determinate gourmet varieties. Gourmet varieties usually have three to five locules and are smaller than the round types (Figure 3).

Egg or Roma tomatoes

Egg or Roma tomatoes have medium sized elongated fruit and may be determinate, semi-determinate or indeterminate and grown as ground or trellis crops (Figure 3).

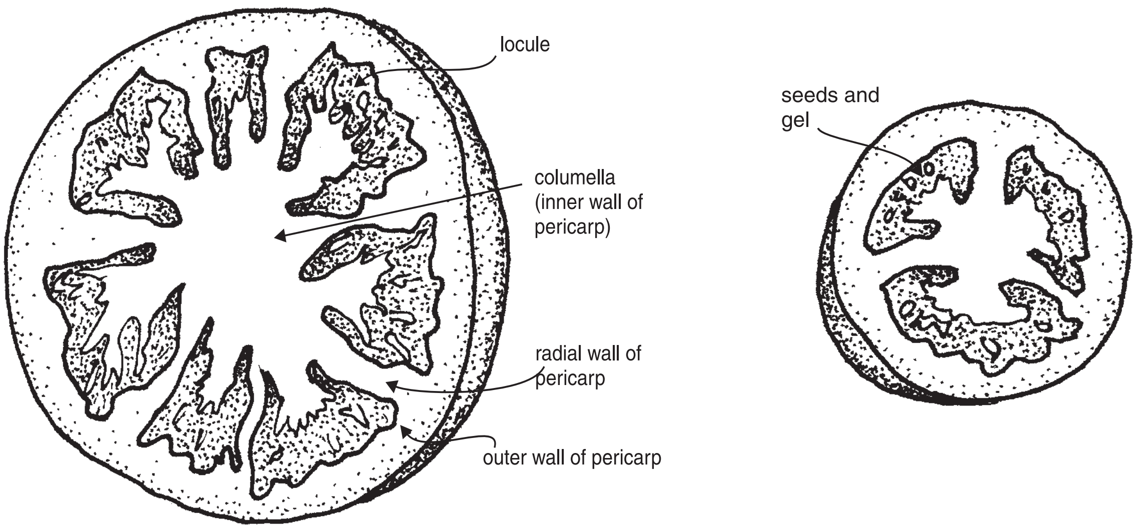


Figure 3. *Diagram of internal parts of multi-locular fruit type (left) and gourmet or egg-type*

Cherry tomatoes

Cherry tomatoes include cocktail and teardrop (pear) tomatoes. They are small fruited with mostly indeterminate bush types and need trellising. They are generally high in sugars and many do not have good disease tolerances.

Cluster tomatoes

Cluster tomatoes are a recent development and are grown for sale as complete clusters or trusses of medium sized fruit. Most are indeterminate bush types so need trellising.

Variety descriptions

more info
Tomato seed companies
Section 6 page 4

The variety descriptions in this kit have been supplied by the seed companies listed in Section 6, *Contacts and references*. Table 4 shows the codes used to identify the seed companies. Table 5 shows the codes used to identify disease resistance or tolerance.

Table 4. *Seed company identification codes*

Code	Company	Code	Company
H	Henderson	S&G	Novartis Seeds
LV	Lefroy Valley	SPS	South Pacific Seeds
RZ	Rijk Zwaan	Y	Yates

Table 5. *Codes for disease resistance or tolerance identification in tomatoes*

Code	Disease	Code	Disease
ASC	Alternaria stem canker	P	Bacterial speck *Pseudomonas syringae* pv. *tomato*
Bw	Bacterial wilt	St	*Stemphylium*
C5	*Cladosporium* race 1 – 5	Tm	Tobacco mosaic virus
F0,1,2, 3	*Fusarium* race 0, 1, 2 or 3	SW	Tomato spotted wilt virus
Fr	Fusarium crown and root rot	V	*Verticillium*
N	Nematodes	Wi	Silvering tolerant

A variety with resistance to *Fusarium* race 2 (F2) will usually also have resistance to race 1, and a race 3 resistant variety (F3) will usually have resistance to races 1 and 2.

Round tomatoes

95-34 RZ (RZ). A determinate, jointless variety producing large, firm, round fruit. Suitable for ground crop production. Tolerance or resistance: Tm, V, F3.

Eagle (Y). Determinate bush suitable for short trellis or ground culture. Fruit are round, attractive, jointless and firm, with an average weight of 140 to 150 g. F3 line used extensively in Bowen and all areas of Queensland. Matures in 10 to 12 weeks. Tolerance or resistance: V, F1,2,3.

Flora-Dade. An open-pollinated, jointless, determinate variety that is best trellised. It was the main variety grown in most areas for many years. It has very firm, deep, globe fruit with an average weight of 130 to 140 g. Matures 10 to 12 weeks after transplanting. Tolerance or resistance: V, F1,2.

Guardian (SPS 7188). Determinate, jointless hybrid. The medium sized fruit have a very deep shape and similar firmness to Typhoon.

Suits the main Bowen season. Features a very tidy blossom end for mid to late spring-summer production and is suggested for use for early May-June and late October-November. Could be used as an alternative in winter for those growers who want smaller fruit size. Tolerance or resistance: V, F3, N, SW.

Hawk (Y). Medium, dense bush for trellising. Fruit are round, attractive, jointless and firm. Useful in areas with bacterial wilt as it has strong tolerance to this disease. Fruit have an average weight of 135 to 150 g. Matures in 11 to 13 weeks. Tolerance or resistance: V, F1,2, Bw.

Indy (SPS 923). Determinate, long shelf life, jointless hybrid. Strong plant with excellent cover for trellis. Excellent size through to last picks. Very firm, deep, tidy fruit with good blossom. Good checking tolerance. Very high yield. Suits Bundaberg late autumn to mid spring. Tolerance or resistance: V, F2.

Longshot (SPS 737). Jointed, large-fruited hybrid with very thick walls and excellent internal colour. Shorter plant with concentrated harvest; five days later to mature than Bermuda. Extra firm, extended shelf life with good tolerance to marking and checking. Tolerance or resistance: V, F2.

Mutiny (TA 516, S&G). Determinate hybrid with large fruit. Matures 72 to 78 days from transplant. Compact, vigorous with good leaf cover under mild growing conditions. Suited to ground and trellis cropping. Sets fruit on the extremity of the plant, making harvesting easier. Fruit are jointless, globe to flat globe with an average weight of 160 to 180 g. Slightly green-shouldered under high light conditions, the fruit show very good shelf life characteristics and firmness. The fruit have an average of between four and five locules and gas well. Suited for outdoor culture and box market. Due to its plant habit, harvest in hot conditions is not suggested. Tolerance or resistance: F1,2,3.

Nemesis (SPS 904). Well suited for early season production in Bundaberg and main season in Bowen, this jointless hybrid has good tolerance to heat and weather, and has been a consistent performer under a wide range of conditions. Strong plant with excellent cover. Deep, oblate, attractive, medium large to large fruit with excellent gassing qualities. Tidy blossom end and good tolerance to checking. Excellent firmness even at mature red. Very high yields of first grade fruit. Tolerance or resistance: N, F2.

Red Label (SPS 7341). This hybrid has proven to be a consistent performer for yield and firmness in 1997 trials. The strong, determinate bush offers very high yields of medium large to large, jointless fruit with good wet weather tolerance. The fruit have a light green shoulder, good internal colour and flavour, excellent postharvest firmness and a very good gassing ability. Suggested for Bowen for harvest June-July and early August. Tolerance or resistance: V, F3.

Red Setter (H). Bush type tomato with excellent heat setting ability, making this variety more suitable to northern summer production. Red Setter is very early, has a concentrated set, compact bush and very firm, jointed fruit. Fruit have excellent shelf life similar to Gourmets. Tolerance or resistance: V, F1,2, Tm, N.

Red Sun (H). Fusarium race 3 resistant variety that is suited to northern Queensland production. Compact bush type with deep oblate, jointless fruit that have good firmness and shelf life. Fruit size and shape is very uniform, resulting in high packouts of desirable size ranges. Tolerance or resistance: V, F1,2,3.

Sequoa (SPS 7220). A consistent performer in Bowen over the 1996/97 season trials. The moderately vigorous, determinate, hybrid plant produces high yields of medium sized, very uniform fruit with light green shoulder. Deep oblate fruit with excellent firmness and tidy appearance. Note: This variety is a medium size only, not large and may be small under winter-early spring conditions. Tolerance or resistance: V, F3.

SPS 896 (SPS). More compact hybrid plant than Starfire with concentrated fruit set. Produces large, jointless fruit. Tolerance or resistance: N, V, F2, Bw.

SPS 925 (SPS). Determinate, extended shelf life, jointed hybrid (joint is easy to remove). Excellent leaf cover on a moderately vigorous plant. Deep globe, medium large to large, very firm fruit with thick walls. Very tidy fruit with reduced cracking and checking and good tolerance to catface. SPS 925 has shown significantly lower numbers of affected fruit under cool flowering conditions. Five days later to mature than Bermuda. Suits early to mid spring production in Bundaberg. Tolerance or resistance: V, F2.

Starfire (SPS). Early maturing, jointless hybrid for early and late spring in Bundaberg. The vigorous plant provides good cover and is best grown under lower nitrogen levels to promote a more concentrated uniform fruit set. Medium sized, deep, oblate fruit with tidy blossom and stem ends. Clean glossy appearance with good tolerance to catface. Tolerance or resistance: Bw.

Tempest (SPS). Determinate hybrid compact plant with an exceptional yielding ability. Extremely uniform, tidy, jointless fruit with good blossom end. Grown in late autumn and late spring in Bundaberg and as a main season crop in Bowen. Tolerance or resistance: F3.

Troppo (SPS 920). Determinate, early season, jointed hybrid (joint is easily removed). Hot-set variety which offers good setting ability under high temperatures. Medium strong, open bush with very good fruit protection; can be trellised or grown on the ground. Extra firm, deep fruit with excellent size and uniformity, and uniform green shoulder. Tidy blossom end. It will hold its flowers during higher temperatures than most varieties. Late December, January, February and early March flowering or March, April, May harvest is generally a high risk period for high temperature burn-off of flowers. Troppo will give growers the ability to reduce the gaps in the autumn harvest. Tolerance or resistance: V, F2.

Typhoon (SPS). Compact, determinate, open hybrid plant with concentrated harvest. Extra firm, jointless fruit with attractive deep shape. Proven wet weather tolerance. Tolerance or resistance: N, F1,2,3.

Waratah (SPS). Arcadia type hybrid with compact plant suited to early season in Bundaberg. High yields of very uniform, medium sized fruit with good depth and excellent wall thickness. Excellent colour, firmness and extended shelf life make it ideal for forward picking. Fruit have a small stem scar and remain firm at full colour. Good tolerance to weather marking and catface. Waratah should only be grown as a ground crop and will also suit early spring harvest. Tolerance or resistance: P.

Zodiac (Y). Medium, dense bush for trellising. Fruit are glossy, firm and jointless. Bred with exceptional disease resistances. Fruit have an average weight of 140 to 150 g. Matures in 10 to 12 weeks. Tolerance or resistance: V, F1,2,3, N, B, SW.

Zola (Y). Tall, determinate, must be trellised. Fruit are exceptionally attractive, firm and good eating. Used extensively for its bacterial wilt tolerance and superior fruit quality. Fruit have an average weight of 130 to 150 g. Matures in 10 to 12 weeks. Tolerance or resistance: N, V, F1,2, Bw.

Gourmet (jointed) tomatoes

74-51 RZ (RZ). New indeterminate introduction for the greenhouse market which combines large size with long shelf life. Average fruit weight is 170 to 180 g. The fruit is glossy and firm with good colour. Highly recommended for hydroponic systems and for long term crops with heating in cooler areas. Tolerance or resistance: Tm, V, F2, Fr, C5.

Accolade (H). Early maturing, 1 to 10 days earlier than major gourmet varieties and has the Rin (long shelf life) gene. Slightly flat with uniform shoulder colour (no green shoulder) and no cracking. Fruit are up to 160 g and have amongst the best shelf life of any fruit. Suitable for all seasons. Suit single pick or cluster, though the cluster attachment is not strong. Tolerance or resistance: Tm, V, N, F1,2.

Angela (TA 1153, S&G). Indeterminate hybrid matures 70 to 80 days after transplanting. Vigorous thin-leafed plant with medium length internodes. Leaf cover is moderate, allowing good air movement around the plant and fruit. Early plant development and flowering affords consistent earliness for harvest. Excellent quality, firm, flat, globe fruit with average size of 55 to 70 mm and extended shelf life. Attractive deep red at maturity with good tolerance to blotchy ripening. Suited for indoor and outdoor culture, box and tray packing. Tolerance or resistance: Tm, V, N, F2, St.

Brillante (FA 179, LV). An indeterminate hybrid combining large, firm fruit with good flavour. The plant is compact and when grown in autumn extra fertiliser is recommended. Tolerance or resistance: Tm, V, F1,2.

Celzus (RZ). Semi-determinate variety producing medium to large, flat, round fruit. The fruit is very early, firm and a deep red. Celzus has excellent disease resistance and is suited to the grower who wants to produce quality tomatoes in the field with low pruning requirement. Recommended for spring, early summer, autumn and winter harvesting. Tolerance or resistance: Tm, V, F2, N, C1 – 5, and field tolerance against *Phytophthora* and *Pyrenochaeta* (corky root).

Citation (H). Winter variety that is better in mid winter than in early winter. Suits winter and spring harvest. Flatter in shape than Award. Fruit weigh about 180 g and have the characteristic gourmet shape but with better colour and size. Colour is particularly better than other varieties in winter. Tolerance or resistance: V, F1,2, Tm.

Daniela (FA 144, LV). Daniela is the world leader, long shelf life indeterminate hybrid and is especially well suited for production under both outdoor and glass/shadehouse systems. Highly productive, it produces outstanding quality, extra firm fruit with a long shelf life. Fruit have an average weight of 120 to 180 g, are uniform, have good colour and are well suited for tray packing. Fruit are a deep, oblate. Plants are very vigorous and can be successfully cultivated under moderately saline conditions. Ideally suited for summer through to winter sowing and have very good fruit setting ability at lower temperatures. Tolerance or resistance: Tm, V, F2.

Darita (TA 774, S&G). Indeterminate hybrid, medium to large size fruit. Medium to medium-late (82 to 89 days) from transplant. Strong, indeterminate with medium to long internodes and strong vigour. The plant is open and has a strong growing tip or head. Fruit size is larger, mainly 75 to 85 mm in diameter and a weight of 180 to 220 g. Fruit is flattened oblate with a large calyx. Trusses are open and have four to five fruit. Suited to tray pack and box markets. Tolerance or resistance: Tm, N, V, F2.

DRW 4610 (RZ). New F3-resistant, indeterminate variety with gourmet quality fruit. Non-green shoulder with medium sized, flat round fruit. Suitable for staked or trellised field production where F3 resistance is required. Tolerance or resistance: Tm, V, F3.

Dynamo (TA 208, S&G). Indeterminate hybrid, medium size fruit. Matures mid-season, 82 to 90 days from transplant. Indeterminate medium vigour with good leaf cover and short internodes. Suited to short crops both indoors and out. Eight to nine fruit trusses can be obtained from a plant height of 2 to 2.5 m. Globe fruit have green shoulders and an average weight of 130 to 140 g. Trusses average seven to eight fruit and are borne in a standard form with few or no split trusses. Very firm, fruit may be left on the vine and harvested at a full, red ripe colour and still have good shelf life. Dynamo colours very well. Suited for tray pack and standard market. Tolerance or resistance: Tm, V, F2, St.

EF 518 (Y). Tall determinate bush that requires trellising. Fruit are very hard, round, with superior colour compared with other extra firm or gourmet types and are exceptionally good eating. Fruit are tolerant of conditions that induce cracking, weather marking or catfacing in other tomatoes. Fruit weigh about 130 to 140 g and mature in 11 to 13 weeks. Tolerance or resistance: V, F1,2.

FA 593 (LV). Indeterminate hybrid tomato of the Daniela type. Vigorous strong plant like Daniela. Medium maturity, deep, oblate fruit weighing 120 to 180 g with very good firmness. Increased production with a strong open plant habit. Medium internodes, very long shelf life. Also suitable as a cluster type. Tolerance or resistance: Tm, V, F2, N.

FA 870 (LV). Indeterminate hybrid tomato of the Daniela type. Vigorous strong plant like Daniela. Early maturing with a similar deep, oblate fruit to Daniela but has a 10% larger fruit size, at an average weight of 140 to 200 g. Ideal for cool season production but can perform well in the heat. Medium internode length, very long shelf life. Tolerance or resistance: Tm, V, F2.

Garland (H). Warm weather variety that has no green shoulder in summer. Plant has good leaf cover for heat. Colour is better and more uniform but shelf life is two days less than Accolade and Garland. Fruit weigh about 140 to 150 g and change colour from green to red very evenly. Avoid winter maturity as fruit may have delayed ripening. Slightly shorter shelf life than other gourmets, but better colour. Best for November to January and May to July transplant. Tolerance or resistance: Tm, V, N, F1,2.

Kristina (TA 1087, S&G). Indeterminate hybrid, very strong and vigorous plant with an open habit and medium to thin head. Matures 75 to 85 days from transplant. Fruit are a high globe with an attractive straight calyx. The fruit are rich red with a very good gloss and firmness. Five to six fruit per cluster should be maintained for best results and to optimise size, which averages 150 to 170 g. Clusters set evenly and are strong against kinking. Fruit have a high Brix at around 4.5%, making for a quality, sweet taste. Suited to indoor, glasshouse and plastic production. Kristina has been developed for use under a high technical level of production (Dutch/Belgium). However, its characteristics lend themselves to a high level of adaptability and therefore Kristina performs well under a wide range of growing conditions. Tolerance or resistance: Tm, V, F2, Fr, C2 & 4, St.

Lightning (SPS 988). A strong, indeterminate, hybrid plant which produces large, deep, oblate fruit weighing about 180 to 200 g with a dark green shoulder and an excellent glossy red, ripened colour. Very good firmness and shelf life. One of the largest commercial hybrids available, with the ability to maintain excellent fruit size in upper bunches. Mid to late season variety suggested as an alternative to Toga for use under cool conditions. Tolerance or resistance: V, F2.

Margarita (FA 558) (LV). A compact, indeterminate plant with remarkable fruit setting ability at high temperature. Recommended for summer and autumn seasons. Tolerance or resistance: Tm, V, F1,2, N.

Marutschka (RZ). Indeterminate variety with medium to large non-green fruit weighing about 140 to 180 g. The glossy fruit have excellent colour and firmness, are nicely lobed and flat. The flavour is sweet and very good. Marutschka is a vigorous plant with long leaves providing excellent protection from the sun. The fruit have a deep-set calyx which minimises harvest damage if calyx retention is chosen. Good sizes are maintained higher up on the plant. Suitable for greenhouse, and staked or trellised field production. Tolerance or resistance: Tm, V, F2.

Mercedes (RZ). Indeterminate variety with medium sized fruit weighing 140 to 165 g. Non green fruit with a deep red, glossy colour. Extremely firm and early. Mercedes gives a very even fruit set, even under adverse conditions. It is very strong against cracking and can be grown under a high fertiliser/watering regime to achieve maximum size. Recommended for late autumn, winter and early spring harvesting. Suitable for greenhouse, and staked or trellised field production. Can be used for truss harvest under certain conditions. Tolerance or resistance: Tm, V, F2.

Meridian (TA 601, S&G). Indeterminate hybrid, medium to large fruit. Mid-season, 73 to 80 days from transplanting. Medium vigour with open habit and short internodes. Suited to short crops both indoors and outdoors. Eight to nine fruit trusses can be obtained from a plant height of 2 to 2.5 m. Globe fruit with an average weight of 170 to 200 g. Trusses average four fruit and are borne in a standard straight truss with little or no split trusses. Very firm, Meridian may be left on the vine and harvested at a full, red ripe colour and still have good shelf life. Suited for both tray pack and standard markets. Tolerance or resistance: Tm, N, V, F2, C1 – 4, Fr, St.

Merit (H). Very large fruit weighing 220 g, amongst the largest seen so far. This variety is cold-tolerant and would suit either winter or summer production.

Nevada (TA 949, S&G). Indeterminate hybrid with round fruit. Matures 75 to 78 days from transplant. Mild weather conditions. A vigorous plant with an open habit. Good cold tolerance. Fruit round, slightly green back, nice colour, medium weight between 140 and 160 g, good adaptation to hormone treatment. Around seven fruit per cluster. Very firm. Attractive, straight calyx. Suited for plastic house and open field. Tolerance or resistance: Tm, N, V, F2, St, Fr.

Red Bluff (TA716, S&G). Indeterminate hybrid, medium sized fruit. Mid-season, 72 to 78 days from transplant. Medium vigour plant with good leaf cover and short internodes. Suited to short crops both indoors and outdoors. Eight to nine fruit trusses can be obtained from a plant height of 2 to 2.5 m. Globe fruit with an average weight of 140 to 150 g. Trusses average six to seven fruit and are borne in a standard form with few or no split trusses. Very firm, Red Bluff may be left on the vine and harvested at a full, red ripe colour and still have good shelf life. Non-green shouldered, it colours very well and has a strong following amongst wholesalers. Suited for tray pack and standard market. Tolerance or resistance: Tm, N, V, F1, St.

Redcoat (NW 547, Y). Indoor/outdoor indeterminate, needs tall trellis and pruning. Fruit are flattened-globe, weighing 140 to 180 g, very hard, red and exceptionally good eating. Superior fruit size, colour, flavour and firmness in humid conditions compared with competitors. Matures in 11 to 13 weeks. Tolerance or resistance: V, F1,2.

Sefora (DRS, RZ). Indeterminate variety with medium large fruit weighing 140 to 160 g, non-green fruit with a long shelf-life (Rin) gene. Particularly suited to short and medium term autumn crops planted from mid-January. Sefora is very early, has short internodes and is high yielding. The fruit are more regular shaped than Recento and present well in trays. Suitable for greenhouse crops. Tolerance or resistance: Tm, V, F2, C1 – 5.

Servane (RZ). Semi-determinate variety producing medium to large flat, round fruit. The fruit is firm and has a non-green shoulder. The calyx scar is small and the bush provides very good leaf cover. Trials are recommended for spring and autumn crops and is well suited to the traditional trellis system for field tomatoes. Tolerance or resistance: Tm, V, F2.

Tango (TA 848, S&G). Indeterminate hybrid. Matures 75 to 85 days from transplant. Mild weather harvest. Has strong vigour suited to cool weather growing where a strong habit is required. Additional laterals may be trained to increase yield potential with a maximum of two advised under ideal growing situations. Tango has very good foliage cover and is strong against disease. Fruit are globe to flat globe with an average weight of 160 g. Slightly green-shouldered under high light conditions, the fruit shows very good shelf life and firmness. Fruit has on average three and five locules and may be left on the vine to semi colour without significant effect on the firmness. Plants will produce seven to eight trusses to a 1.8 m height under cool conditions. Suited for indoor and outdoor culture, box and tray pack. Tolerance or resistance: Tm, V, F1.

Thunder (SPS 980). Extra long shelf life, indeterminate hybrid. The variety has deep oblate fruit with excellent uniformity, colour and improved flavour over many gourmet types. The tidy, medium-large fruit weigh about 170 to 200 g, with semi-green shoulder. The slightly less vigorous plant has an open habit with a concentrated harvest period. Tolerance or resistance: V, F2.

Toga (SPS 860). A mid maturing, jointed, hybrid variety which produces high yields of smooth, oblate (slightly flattened) fruit weighing 140 to 160 g with a semi-green shoulder. Medium long shelf life with very good firmness and uniform ripening. Fruit holds well on the bush with consistent development of fruit throughout trusses with similar fruit size to Daniela (FA144) in warm weather. It has a strong, indeterminate, semi-open bush habit, which can be pruned to one header for cool season production to help maintain fruit size. Tolerance or resistance: V, F2, N.

Tracer (NW 6060, Y). Extra firm, short determinate bush, best grown as a ground crop. Fruit are very hard, round, uniform shouldered and jointed. Test market indicates consumer preference for its superior colour and flavour. Fruit weigh about 140 to 150 g. Matures in 10 to 12 weeks. Tolerance or resistance: V, F1,2,3.

Trophy (H). Uniform fruit weighing 180 to 200 g, suited to both winter and summer production. Larger fruit and an open vigorous bush suit winter pick. Fruit have slight green shoulder which disappears when ripe. Fruit will ripen normally over winter unlike some other gourmet varieties. Two weeks earlier than common gourmet varieties in winter. Stem and calyx remain fresh for two to three weeks. Vigorous bush which performs better in the open field, on trellis than other gourmet varieties. More uniform fruit with good colour. Fruit are rounder and not prone to puffiness. Good shelf life. Tolerance or resistance: V, F1,2, Tm.

Roma or egg types

Brione (RZ). An improved Sixtina type highly recommended for trial. Larger and more productive than Sixtina with better vigour and leaf cover. It is later and has the same excellent fruit quality as Sixtina for the fresh market. Tolerance or resistance: V, F2, St, P.

Colt (Y). Short, dense bush for trellising. Fruit are long, cylindrical, Roma type. Very high yield or classy, good eating fruit weighing 70 to 80 g. Matures in 10 to 11 weeks. Tolerance or resistance: V, F1,2.

Early Peel (SPS). Early maturing, hybrid Roma type. Determinate bush for ground or short trellis production. Excellent yield with concentrated harvest and good size required by markets. Good disease tolerance.

Early Peel Improved (SPS). Determinate hybrid plant with concentrated fruit set. Very firm, large, pear-shaped fruit. Has excellent firmness and internal colour for drying and bottling. Good tolerance to wet weather conditions. Tolerance or resistance: Tm, V, F2, N, P.

Eggy (TA 709, S&G). Hybrid, distinctly egg-shaped tomato. Medium late, 82 to 90 days from transplant. Indeterminate with medium vigour and high disease tolerances. Good leaf cover protects the high yielding clusters of fruit. Easily maintained, the plant has short internodes and will set under both cool and warm conditions. Fruit weigh about 90 g, have thick walls and are very tasty. Trusses are averaging six to eight fruit and are uniform. Fruit colour well and are very attractive. Suits fresh market and also sauce. Tolerance or resistance: Tm, V, F2, C1 – 3, P, St.

Futura (Y). Determinate and more suitable for trellising than others of this type. Fruit are large and very long Roma types, very thick walled fruit and of exceptional colour and taste. Superior disease tolerance. Weigh 75 to 90 g. Matures in 10 to 11 weeks. Tolerance or resistance: V, F1,2, N, P.

Italian Pride 38 (LV). A determinate, egg-shaped variety producing medium large fruit weighing 100 to 110 g. Fruit are firm with excellent colour. Tolerance or resistance: V, F2, P.

La Rossa (TA 329, S&G.) Determinate hybrid, Roma or pear-shaped fruit with long blocky characteristics. Mid early season, matures 22 to 78 days from transplanting. Vigorous vine, large plant frame, suited to single or twin row culture. The plant trains well between wires for trellis culture. Foliage is heavy, providing excellent cover. Fruit are jointed, uniform and green shouldered. Thick walls, very good interior colour, mostly two to three locules. Very little green core. Very firm and good taste. Suited to open field, ground and trellis culture. Tolerance or resistance: V, F1,2.

Marzano (H). High quality, Roma type with 60 to 70 g fruit that have excellent colour. A medium size bush. Fruit are large and blocky with a high degree of uniformity of size and shape. Tolerance or resistance: V, F1,2, N, ASC.

Montano (TA 742, S&G). Hybrid Roma or pear-shaped fruit. Matures 82 to 87 days from transplant. Determinate with strong vigour and increased leaf volume over La Rossa. More adapted to warm to hot growing conditions, the plant is more compact and very high yielding. Average weight of 90 g. Colour is very good with a rich red on maturity and very little hollow fruit compared to other Roma types. The yield is good with a Brix level of about 5.5%. Suited to processing and fresh market. Tolerance or resistance: V, F1,2, N.

Ovata (RZ). Indeterminate, long shelf life variety with medium vigour and short internodes. Long oval 90 to 100 g fruit with good firmness and non-green shoulder. Easy setting and uniform maturity within the truss. Suitable for greenhouse, and staked or trellised field production. Tolerance or resistance: Tm, V, F1, C3.

Reggae (TA 1068, S&G). Hybrid, eggy type. Early season variety. Indeterminate plant with medium vigour. Internodal length is short and produces large clusters often divided with 10 to 15 fruit. Good heat setting and cold setting ability. Eggy shaped fruit with no green back and a medium size of 100 to 110 g. Fruit can be up to 8 cm long and about 4 cm wide, tapering to a slight point at the blossom end. Very good red colour and firmness. Suits glasshouse, plastic and open field staking. Tolerance or resistance: Tm, V, F0, C1 – 3, St.

Rhomba (SPS 901). Extra large, deep fruit with a higher percentage of the larger sizes. Determinate, hybrid plant with concentrated harvest and high yields. Tolerance or resistance: V, F2.

Romano (TA 1010, S&G). Elongated, San Marzano type hybrid. Matures 80 to 85 days from transplant. Indeterminate, semi vigorous with strong dark green foliage and stem. Ideally suited to indoor production, the plant has a medium length internode. Elongated fruit up to 15 cm long. Fruit, weighing up to 150 g, are slightly green shouldered with a gloss green and red colour. Bred specifically for indoor culture suits indoor shade, plastic and glass. Tolerance or resistance: Tm, V, F2, N, Fr, St.

Sixtina (RZ). Sixtina is a very early, semi-determinate variety with oval fruit. Fruit shape is similar to Roma but fruit weight is higher, 90 g average. Sixtina has an excellent fruit quality, with smooth, uniform coloured fruit and very good shelf-life. Recommended for trellis field production, Sixtina is highly suitable for the fresh market. Tolerance or resistance: V, F2, St, P, powdery mildew.

SPS 942 (SPS). Large, tapered Roma/pear-shaped fruit. Strong determinate, hybrid plant. Excellent yield and uniformity with concentrated fruit set. Tolerance or resistance: V, F2.

SPS 965 (SPS). Large, tapered Roma type. Taller, open, hybrid plant with high yield. Good weather tolerance. Tolerance or resistance: V, F2.

SPS 967 (SPS). Large, smooth, cylindrical Roma type hybrid. Taller open plant habit with extended yield for trellis. Shows good weather tolerance. Tolerance or resistance: V, F2.

TMI 3744 (LV). Produces large oval fruit (110 to 130 g) with gourmet type quality. Plants are indeterminate and need trellising. Tolerance or resistance: Tm, V, F2, N Fr, St, and good tolerance to blossom-end rot.

Vesuvio (H). Large Roma type similar to Marzano with slightly larger 70 to 80 g fruit, with higher solids making it more suitable for drying. Excellent fruit colour, large size and uniformity make this a stand out variety. Tolerance or resistance: V, F1,2, N, ASC.

Cherry tomatoes

Bite Size (Y). Indeterminate and needs a tall trellis. Very high yields of round, sweet and juicy 20 to 30 g fruit. Matures in 9 to 10 weeks. Tolerance or resistance: V, F1,2, N.

Camelia (FA 819, LV). Hybrid, cocktail type. Medium maturity. Deep globe 15 to 40 g fruit, slightly larger than Naomi (BR 124). Extra long shelf life. Tolerance or resistance: Tm, V, F1.

Cerasa (RZ). Indeterminate, small cocktail variety. Average fruit weight is 18 to 20 g. It has a long shelf life and is strong against fruit splitting. The fruit size is exceptionally uniform, even higher up the plant. Suitable for trellised field production. Tolerance or resistance: Tm, V, F2, N, C5.

Cherry Gold (TA 767, S&G). Indeterminate, hybrid early to early to mid-season variety. Suited to staking or trained culture. Vigorous, strong plant which may be trained to multiple leaders. Leaf volume is good and gives ample protection from the sun. High numbers of round, yellow cherry tomatoes weighing about 20 g are produced in clusters. The clusters are evenly spaced up the plant and may contain up to 15 fruit. It is tolerant to splitting and has good eating qualities. Staked, pruned culture. Tolerance or resistance: Tm, F0, St.

Cherry Red (TA 704, S&G). Indeterminate, mid-season, hybrid variety with medium vigour and strong stem. Leaf cover is good and clusters are close, due to its relatively short internodal distances. Fruit are similar to Sweet Bite (Super Sweet 100) in characteristics, but are slightly larger. Clusters are medium long and produce excellent yields of rich red fruit. Stake and prune. Tolerance or resistance: Tm, F0.

Cherub (SPS 7415). Determinate, red truss, hybrid, cocktail cherry tomato. Features high yields with excellent uniformity within the truss. The very sweet flavour and brilliant holding ability have created very good interest from major retail stores. Tolerance or resistance: V, F2.

Cockatoo (TA 987, S&G). Hybrid, cocktail tomato. Matures 78 to 88 days from transplant. Indeterminate with medium strong vigour and open plant habit, strong trusses that do not kink easily. Suited to both indoor and outdoor wire-trained culture. Pruning suggested. Fruit are round and weigh about 40 to 60 g. Clusters may produce as many as 12 fruit, but eight is more common. Ripens evenly, may be used as a cocktail size fruit or harvested as a cluster. Indoor and outdoor, single, punnet or box markets. Tolerance or resistance: Tm, V, F2.

Cocktail (H). Possibly the highest yielding cherry tomato variety commercially available, with 15 to 18 quality fruit per truss not being unusual. The fruit are 20 to 25 mm in diameter. Cocktail is the preferred variety as it maintains size all the way up the plant. Vigorous growth habit and very tolerant to stress.

Cocktail Supreme (S&G). A larger fruited, hybrid, cocktail size (diameter 30 mm) fruit borne by a vigorous, indeterminate bush which reliably sets a heavy crop of sweet, large fruit. Uniform size, excellent quality.

DRC 1025 (DRS, RZ). Indeterminate, cocktail tomato which is very productive. Average fruit weight is 28 to 30 g and is very strong against splitting. Suitable for trellised field production. Tolerance or resistance: Tm, V, F2, N, C5.

Josefina (BR 139, LV). Medium maturity hybrid. Globe shape, 10 to 25 g fruit, very good firmness. Extra long shelf life. Tolerance or resistance: F1.

Naomi (BR 124, LV). Hybrid, cocktail type. Medium maturity. Deep globe 15 to 30 g fruit with very good firmness. Extra long shelf life. Tolerance or resistance: V, F1.

Orange Sunrise (TA 700, S&G). Early to early-mid-season variety. Vigorous, indeterminate hybrid which grows to more than 2 m tall when pruned. Suited for staking or trained culture. The plant has dark green foliage which gives good protection from sunburn. Orange fruit are round with the average fruit about the same size as a 10 cent piece. Sugars are very high in mature fruit. Excellent taste. Suited to staking and pruning. Tolerance or resistance: Tm, F0.

Presto (TA 752, S&G). A determinate hybrid with round fruit. A medium-early variety, vigorous plant with good leaf cover. The plant can be grown as a ground or trellis crop and requires no pruning. The foliage is dark green, with medium to large, thick textured leaves. Fruit are round, non-green back, deep red, with an average weight of 20 to 30 g and average diameter of 23 to 27 mm. About 11 fruit per cluster. Very firm. Suited to both indoor and open field. Tolerance or resistance: V, F1.

SPS 7412 (SPS). Mid-maturing, semi-determinate, hybrid, red cherry tomato. Very clean, attractive, round, medium-small 30 mm, jointless fruit. Excellent weather tolerance. Tolerance or resistance: V, F2.

SPS 7413 (SPS). Very early maturing, hybrid, determinate, red truss, long shelf life, cherry tomato. Produces high yields of jointed, round fruit (30 to 35 mm diameter) with excellent firmness at red. Tolerance or resistance: V, F2.

SPS 957 (SPS). Long shelf life type, hybrid with strong indeterminate plant. Fruit are medium sized, 30 mm, with excellent colour and brilliant flavour. Extra long shelf life and good tolerance to splitting. Tolerance or resistance: V, F2.

Stoplight (SPS). Large hybrid with vigorous, determinate, plant habit. Fruit are round, 20 to 35 mm diameter, and firm in early picks, with slightly smaller later picks. Fruit hold well at coloured stage with good shape and firmness. Consistently good shape, even under hot conditions. Easy to handle with a bush that will generally only go to four or five wires. Tolerance or resistance: V, F2.

Super Sweet 130 (Y). Indeterminate and needs a tall trellis. Good heat tolerance. Fruit are glossy, attractive and very sweet, 15 to 25 g. Matures in nine to 10 weeks. Tolerance or resistance: V, F1,2, N.

Sweet Bite (Y). Indeterminate and needs a tall trellis. A small fruited alternative to Bite Size and Super Sweet 130. Fruit weigh 10 to 15 g. Matures in 9 to 10 weeks. Tolerance or resistance: V, F1.

Teardrop. Indeterminate, yellow, pear-shaped fruit similar to the variety Yellow Pear.

Yellow Pear (Y). Jointed, indeterminate, open pollinated, small, yellow, pear-shaped variety. Matures 9 to 10 weeks after transplanting.

Clear yellow, 10 to 15 g with a waxy finish and mild flavour. Requires trellising.

Cluster tomatoes

Acadia (FA 556, LV). Indeterminate hybrid tomato. Deep, globe fruit, 100 to 130 g with uniform ripening and very good firmness with extended shelf life. Medium maturity. Tolerance or resistance: Tm, V, F2, N.

Emanuelle (FA 831, LV). Indeterminate, hybrid tomato. Vigorous strong plant like Daniela. Medium maturing, 140 to 220 g globe fruit. Extended shelf life. Tolerance or resistance: Tm, V, F2.

Monika (TA 980, S&G). Indeterminate hybrid, medium sized, cluster harvest. A mid-season variety. Medium-strong vigour with good leaf cover and medium internodes. Suited to short or long crops both indoors and outdoors. Six to seven fruit trusses can be obtained from a plant 2 to 2.5 m high. Fruit are globe/round with an average size of 125 g. Trusses average five to six fruit and are borne in a tight bunch form. Very firm, Monika may be left on the vine and cluster harvested at a full, ripe red colour. Suited for box packing of whole cluster cut 5 cm above the first fruit set on each cluster. Tolerance or resistance: Tm, V, F0, N.

Planting times

Table 6 shows the varieties and planting and harvesting times for the main production districts. Harvesting is 10 to 16 weeks after planting, depending on variety, temperature, and whether seed or transplants are used.

Table 6. *Tomato varieties grown in the main growing districts*

	Varieties			
District	**Rounds**	**Gourmets**	**Roma (egg)**	**Cherry tomatoes**
Bowen	Eagle, Tempest	Daniela (FA144), Red Bluff	Colt	
Bundaberg	Flora-Dade, Tempest, Troppo	Celzus, Daniela (FA144), Red Bluff, Redcoat	Early Peel, La Rossa, SPS 965	Bite Size, Cocktail, Cocktail Supreme, Super Sweet 130, Sweet Bite, Teardrop, Yellow Pear
Granite Belt	Starfire, Tempest, Troppo, Zola	Daniela (FA144)	Colt, Early Peel Improved, La Rossa, Rhomba (SPS 901)	
South-east Queensland (Lockyer Valley)	Indy (SPS 923), Red Setter, Tempest, Troppo, Zola	Daniela (FA144), Red Bluff, Thunder (SPS 980)	Futura	Super Sweet 130

Nutrition

Adequate plant nutrients are necessary to produce high yields of good quality fruit. The most critical nutrient in tomato growing is nitrogen, but high levels of phosphorus and potassium are also important.

Plan your nutritional program

Getting the soil ready

To provide adequate nutrition for your crop you need to test the soil to get an analysis of what elements are available in it and, perhaps more importantly, what elements will not be available to the crop. This information is then used to adjust the soil to the crop's requirements before planting and to plan a nutritional program that will give the plants the best chance to produce a high yield of good quality fruit.

Soil analysis. A soil analysis takes the guess work out of fertiliser scheduling. Take the sample six to eight weeks before your intended planting date. Follow the sampling instructions supplied by the laboratories.

A soil analysis measures the pH, conductivity, organic matter and the level of nutrients in the soil. Results will be interpreted by the laboratory and should be back in about two weeks, allowing time for the treatments to be incorporated into the soil. Your experience of the block of land, and the way you wish to manipulate the growth pattern of the crop, will influence your interpretation of the soil analysis.

Soil pH. The pH level is a measure of the soil's acidity or alkalinity on a scale from 0 to 14, with 7 being neutral. A pH of 5 is 10 times more acid than a pH of 6. Tomatoes prefer a slightly acid soil, around 6.0 to

6.5. In this range, most major and trace elements present in the soil are available to the plants, without being at toxic levels. Many Queensland soils are acidic and require the addition of lime or dolomite to raise the pH. A complete soil analysis will show which form is most suitable by showing the available levels of calcium and magnesium. Table 7 is a guide to the application rates for lime or dolomite.

Table 7. *Lime or dolomite needed to raise soil pH to about 6.5*

Soil type pH range	Sandy loam t/ha	Loam t/ha	Clay loam t/ha
4.5 – 5.0	5.00	6.25	7.50
5.0 – 5.5	2.50	3.75	5.00
5.5 – 6.0	1.25	2.50	3.75

Gypsum. Application of gypsum will increase soil calcium levels but does not change soil pH. Naturally occurring gypsum is preferred to phosphogypsum in vegetable crops because of the cadmium in phosphogypsum. It takes about one year for the effects of gypsum to become fully apparent. Apply gypsum before the wet season so that it can leach accumulated salts beyond the root zone well before planting, thus improving the soil structure. Soil must have good internal drainage to benefit from gypsum. Table 8 shows the appropriate management of calcium, magnesium and pH.

An application of 5 to 10 t/ha of gypsum can benefit heavy clay loams that have high sodium levels and a pH higher than 8.0. Table 8 is a guide to which product is most suitable for your situation.

Table 8. *Management of calcium (Ca), magnesium (Mg) and pH*

Recommended action	Soil nutrient status							
	pH high				pH low			
	Calcium high		Calcium low		Calcium high		Calcium low	
	Mg high	Mg low	Mg high	Mg low	Mg high	Mg low	Mg high	Mg low
Gypsum 1.0 – 2.0 t/ha			✓	✓				
Dolomite 2.5 – 5.0 t/ha						✓		✓
Lime 2.5 – 5.0 t/ha					✓		✓	
Magnesium sulphate ($MgSO_4$) 100 – 250 kg/ha		✓		✓		✓		

Fertilisers

Tomatoes require careful nutritional management to ensure high yields of top quality fruit. Follow the recommendations of your soil analysis when applying fertiliser. Nutrients must be balanced to achieve early vigorous vegetative growth followed by heavy flowering and fruit set on less vigorous growth. This should lead to a high yield of firm, large fruit.

Fertilisers are commonly sold as mixtures of nitrogen (N), phosphorus (P) and potassium (K). The percentage of each of these elements in the mix is expressed as a ratio of N:P:K. For example 100 kg of a fertiliser with an N:P:K ratio of 14:15:13 contains 14 kg nitrogen, 15 kg phosphorus and 13 kg potassium.

Fertilisers should be applied before planting (pre-plant) and as side dressings as the crop grows. The fertiliser program should be based on soil, leaf and sap analysis. Table 9 shows a range for the total requirements of the major elements nitrogen, phosphorus and potassium to grow a tomato crop.

Table 9. *The total requirements (in kg/ha) of the major elements for a tomato crop*

Nutrient	Minimum (Fertile soil)	Average	Maximum (Poor soil)
Nitrogen (N)	50 kg	110 kg	160 kg
Phosphorus (P)	30 kg	60 kg	100 kg
Potassium (K)	60 kg	120 kg	200 kg

Major elements

Nitrogen

Nitrogen is required for plant growth and vigour. Plant size, leaf area and the number of flowers produced depend on an adequate supply of nitrogen. Insufficient nitrogen will result in poorly grown plants and low yields. If excess nitrogen is available to the plants, fruit set and quality will be poor and fruit will be soft and puffy. Nitrogen is easily leached from the soil by excess rain or irrigation.

Phosphorus

Phosphorus is required during the early stages of the crop for plant development, root growth and flower initiation. Phosphorus deficient plants have an open, sparse appearance with purple discolouration of the leaves. The potential yield of the crop is reduced if adequate phosphorus is not available to the seedling and young plant. Phosphorus is not readily leached from the soil.

Potassium

Adequate potassium is required to produce high quality fruit. A good supply of potassium reduces puffiness and blotchy ripening and improves fruit shape and firmness. Potassium is leached from the soil by excess rain or irrigation, but not as easily as nitrogen.

Pre-plant (basal) fertiliser

The pre-plant or basal fertiliser should provide an even, vigorous, but not over vegetative tomato bush. The plants should develop a strong root system and early bush structure that can support a heavy crop.

About 30% of the total nitrogen requirement, all the phosphorus and 30 to 50% of the potassium should be applied before or at planting.

Where methyl bromide is used as a soil fumigant, pre-plant nitrogen may need to be reduced by 20% to prevent excessive vegetative growth.

Apply the pre-plant fertiliser to the soil surface in a 60 cm wide band and incorporate the fertiliser with a rotary hoe during final soil preparation or bed-forming. Where phosphorus may be tied up in some soils (mainly krasnozems and red earths), basal fertilisers are drilled into the bed in narrow bands 10 cm to the side and below the plant roots.

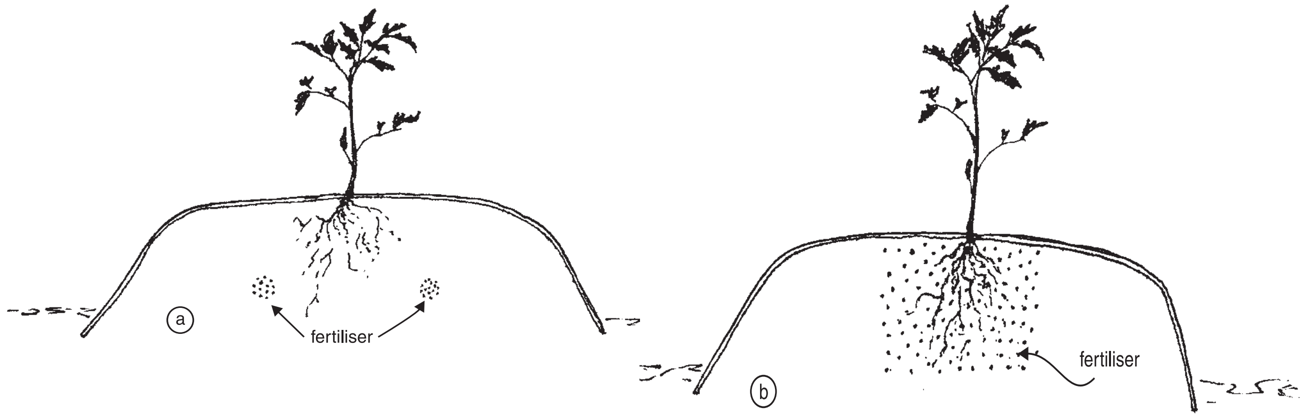


Figure 4. *Pre-plant fertiliser, drilled (a) and banded (b)*

Pre-plant fertiliser requirements should be determined from the results of a complete soil analysis. The pre-plant fertiliser required will contain mainly nitrogen, phosphorus and potassium. Tomatoes require higher levels of phosphorus than most other crops, particularly during the early growth stages. In the absence of a soil analysis, Tables 10 and 11 are a guide to pre-plant fertiliser requirements and application rates.

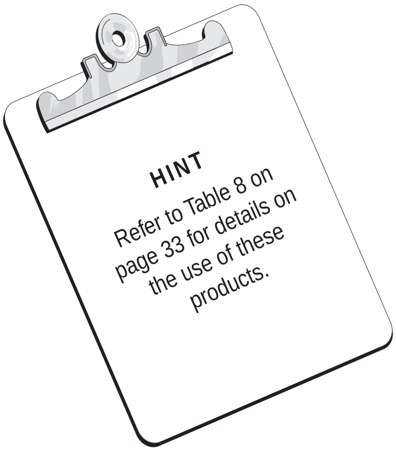
Table 10. *A guide to pre-plant fertiliser requirements*

Nutrient	Low phosphorus soil	High phosphorus soil
Nitrogen (N)	40 – 60 kg/ha	40 – 60 kg/ha
Phosphorus (P)	60 – 70 kg/ha	10 – 30 kg/ha
Potassium (K)	50 – 60 kg/ha	50 – 60 kg/ha

Table 11. *A guide to pre-plant fertiliser rates*

Soil phosphorus level	Fertiliser N:P:K	Quantity to apply	
		kg/ha	kg/20 m at 1.8 m rows
Low phosphorus (P) soil	13:15:12	310 – 500	1.1 – 1.8
	5:6:5	800 – 1200	2.9 – 4.3
High phosphorus (P) soil	12:5:14	350 – 500	1.3 – 1.8

Other elements required in relatively large amounts include calcium (Ca), magnesium (Mg) and sulphur (S).



Sulphur is usually found in sufficient quantities in most commercial N:P:K fertilisers, superphosphate, gypsum and sulphate of potash. Lime, dolomite and gypsum are sources of calcium. Dolomite and magnesium sulphate are sources of magnesium.

If a magnesium deficiency occurs apply magnesium sulphate ($MgSO_4$) as a foliar spray at 1 kg/100 L or apply 10 to 20 kg/ha as a fertigation through the trickle irrigation system.

Monitor plant nutrients and fertilise

The pre-plant fertiliser will generally grow the crop up to first fruit set. If leaching rain occurs before this time, apply 40 kg/ha of urea to unmulched crops after each significant fall to maintain adequate early vegetative growth up to first fruit set. Rain is unlikely to leach fertiliser out of the root zone of crops on plastic mulch.

Applying fertiliser every few weeks without knowing whether the plants need it wastes money and is environmentally irresponsible. Take the guesswork out of fertiliser applications by monitoring plant nutrient levels. If test results are unavailable, Table 11 is a guide to fertiliser applications.

Plant nutrient monitoring

Leaf testing is a benchmarking tool that has little direct relevance to the current crop. Its value is in judging the fertilising schedule used in this crop and how it may be improved for the next crop. Optimum values are given in Table 12. Use the results of soil and leaf testing to refine the fertiliser schedule for the next crop.

Do a leaf analysis just as the first fruit mature. Buy a tissue sampling kit from your farm supply outlet and follow its instructions. Your results will be interpreted by the laboratory analysing your sample. The optimum nutrient levels for the youngest fully mature leaf taken when the first fruit mature, are shown in Table 12.

Table 12. *Optimum leaf nutrient levels (based on dry weight)*

Nutrient	Normal level
Nitrogen (N)	4.0 – 5.5%
Phosphorus (P)	0.4 – 0.7%
Potassium (K)	3.0 – 5.0%
Calcium (Ca)	1.5 – 3.0%
Magnesium (Mg)	0.4 – 0.8%
Sulphur (S)	0.4 – 1.0%
Sodium (Na)	0 – 0.4%
Chloride (Cl)	0 – 1.6%
Copper (Cu)	5 – 200 ppm
Zinc (Zn)	20 – 200 ppm
Manganese (Mn)	25 – 500 ppm
Iron (Fe)	100 – 300 ppm
Boron (B)	25 – 100 ppm

Source: Weir and Cresswell, NSW Agriculture, 1993.

more info
Doing your own sap tests
This section page 40

Sap testing is a means of rapidly assessing a plant's nutrient status during crop growth. This is a recently developed test and has a 24 hour turn-around time. It can be used to highlight deficiencies of any essential element or to monitor the nitrate and potassium levels during the crop cycle. Sap testing allows growers to manage the crop more precisely and to correct any nutrient problems before yield or fruit quality are affected. Sap testing involves collecting leaf stalks (petioles) of the youngest fully expanded leaves, usually the fourth or fifth back from the growing point, extracting sap with a garlic press, and analysing the nutrient content of the sap. Sap testing may start at first flowering and continue in trellised crops until after harvesting has begun. Figure 5 shows which leaf to collect.

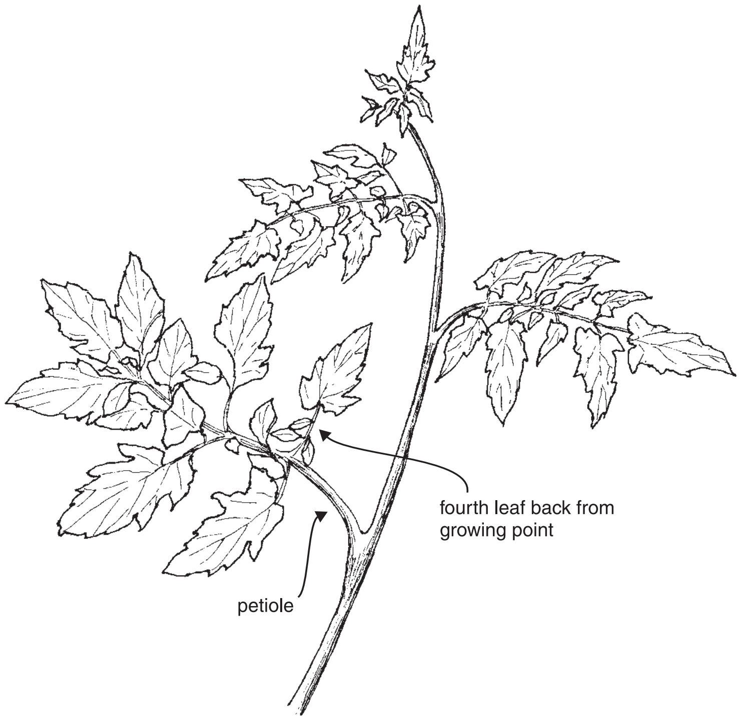


Figure 5. *The youngest fully expanded leaf from the growing point*

more info
Sap testing services
Section 6 page 7

You can do the tests yourself, but we recommend you use a commercial sap testing service which can perform the tests and advise on the results. Sap testing for nitrogen, phosphorus, potassium, calcium, magnesium and zinc should be done at least monthly and ideally every two weeks. Other nutrients should be tested at least three times during the season.

Nitrogen and potassium are the two most easily managed and influential nutrients in tomatoes. Table 16 on page 42 indicates the optimum range for these nutrients in southern Queensland. The levels are a little lower in north Queensland.

Apply side dressings

Leaf and sap tests are useful guides when deciding on side dressings and are usually available from the same laboratories as soil analysis. Refer to Tables 12 and 16 for the recommended levels. Table 13 indicates the additional N:P:K requirements of the crop.

Table 13. Approximate additional N:P:K requirements in kg/ha

Nutrient	Minimum (Fertile soil)	Average	Maximum (Poor soil)
Nitrogen (N)	30 kg	60 – 70 kg	120 kg
Phosphorus (P)	0 kg	0 kg	10 kg
Potassium (K)	40 kg	80 kg	130 kg

Overhead or furrow irrigated crops

The fertiliser schedule used for overhead or furrow irrigated crops should be based on the results of soil, leaf and sap tests. If these are unavailable, the following could be used as a guide:

- When the first fruit are about 25 mm in diameter, apply a side dressing of a 15:4:11 N:P:K fertiliser at 250 kg/ha (900 g/20 m row if rows are 1.8 m apart). Drill in, then reform drains.
- If overhead irrigation sprays are used, further side dressings of potassium nitrate at 125 kg/ha (450 g/20 m row) may be applied at two-weekly intervals, starting from four weeks after the first side dressing. Make the last application three weeks before final harvest. The side dressings should be incorporated into the soil with at least 25 mm of irrigation.

In Queensland almost all tomato crops are grown using trickle irrigation.

Fertilising through irrigation water (fertigation)

Fertigation has advantages over manual application of solid fertilisers because it uses less labour. With a trickle system fertilisers can be applied more regularly and closer to the roots. Before fertigating get a water testing laboratory to analyse your irrigation water.

With fertigation fertiliser is dissolved in water in a drum or tank and sucked or injected through the watering system. Fertilisers used must be highly soluble to avoid damaging the pump and blocking pipes. Suitable fertilisers are listed in Table 14. There is also a range of soluble commercial fertiliser blends.

Table 14. Soluble fertilisers for fertigation

Fertiliser	Main nutrient supplied
Urea	Nitrogen
Calcium nitrate	Calcium, nitrogen,
Ammonium nitrate	Nitrogen
Potassium nitrate	Potassium, nitrogen
Potassium chloride	Potassium
MAP (mono ammonium phosphate, technical grade)	Nitrogen, phosphorus
MKP (mono potassium phosphate)	Potassium, phosphorus

The fertiliser schedule used should be based on the results of soil, leaf and sap tests. If these are unavailable, the rates in Table 15 could be used as a guide.

Table 15. A guide to fertigation of trellised tomatoes grown in southern Queensland

Plant stage	Fertiliser	Rate (kg/ha)	Comments
Flowering to early fruit set	Potassium nitrate (KNO_3) Calcium nitrate ($CaNO_3$)	12.5 – 25 10 – 20	Apply weekly.
	MAP or similar soluble blends	10	If indicated by sap test, apply at first flowering and the following week.
Fruit golf ball size	Potassium nitrate (KNO_3)	20 – 30	Apply weekly.
	Ammonium nitrate (NH_4NO_3)	10 – 20	Apply if more nitrogen is indicated by sap test.
Fruit fill	Potassium nitrate (KNO_3) Calcium nitrate ($CaNO_3$)	15 – 25 10 – 20	Apply weekly.
From first mature green fruit through harvest	Potassium chloride (KCl) OR Potassium sulphate (K_2SO_4)	10 – 25	Apply weekly if indicated by sap test. Use K_2SO_4 if chloride levels are high. Do not exceed these rates.

Source: John Hall, Crop Tech Research

Growers of trellised crops reduce nitrogen application during harvest and some apply potassium fertilisers as potassium sulphate or muriate of potash to improve fruit quality and reduce vegetative growth. If soil or water chloride levels are high, use potassium sulphate. Table 15 shows rates of potassium sulphate and muriate of potash which may be applied. Do not exceed these rates or yields may be reduced.

For ground crops grown in north Queensland, growers may apply 10 to 12 kg/ha of potassium nitrate (KNO_3) and calcium nitrate ($CaNO_3$) in alternate weeks, however, side dressings are not always necessary. Most ground crops are not fertilised during harvest.

Note. Overuse of potassium and calcium can induce magnesium deficiency in soils low in magnesium or with low cation exchange, that is less than 2 milli-equivalents per 100 g (meq %) of soil on your soil test. After every second application of potassium nitrate or calcium nitrate, apply 15 to 20 kg/ha of magnesium sulphate.

Trace elements

Apply trace elements if deficiencies have developed in previous crops or where soil analysis results suggest a possible deficiency. Some are best applied to the soil before the final cultivation. Soil applications will often last for a few years, whereas foliar applications only benefit the plants to which they are applied.

Do not exceed the rates suggested in this kit. The addition of urea at 500 g/100 L of water will increase the leaf's absorption of trace elements. Spray to wet the leaves only, not to have runoff, otherwise leaves may burn. Apply foliar nutrients separately, not combined with pesticide sprays.

Boron

Boron deficiency is more likely in sandy neutral to alkaline soils, particularly if they have recently been heavily limed or are low in nitrogen.

If boron is deficient, spray 2 to 3 kg/ha of Solubor onto the soil during final land preparation. Alternatively apply a foliar spray of Solubor (200 g/100 L) about three weeks after transplanting and at early fruit set.

Solubor is NOT compatible with zinc sulphate heptahydrate and they should not be mixed.

Molybdenum

If deficient, apply molybdenum as sodium molybdate (60 g/100 L) or another molybdenum source, in the nursery and again about three weeks after transplanting.

Zinc

Zinc deficiency is common in many Queensland soils. The best way to correct zinc deficiency is to spray either zinc sulphate heptahydrate on the soil at 30 kg/ha or zinc sulphate monohydrate at 20 kg/ha, three weeks before planting and work it in.

Apply zinc sulphate heptahydrate (100 g/100 L) as a foliar spray if a deficiency becomes apparent.

Foliar fertilisers

Foliar fertilisers contain soluble nutrients which are sprayed on the crop and absorbed through the leaves. These may be as simple as urea or potassium nitrate dissolved in water or a 'shotgun' mixture of many major and trace elements. They can be useful when plants are under stress from waterlogging, disease or nematodes affecting the roots. Foliar fertilisers help the plants survive until new roots develop and can again support the plant.

Calcium nitrate ($CaNO_3$) at 800 g/100 L can be sprayed on plants and young fruit in hot weather or where there is a known risk of blossom-end rot because of low soil calcium levels.

Do-it-yourself sap testing

Sap analysis procedures are somewhat complex so we recommend you use sap testing consultants or a sap testing laboratory. Where these services are unavailable, the following guidelines may be useful. Make sure your meter has been calibrated and check it regularly.

Essential equipment:

- garlic press
- small plastic capped tube

- 1 mL plastic pipettes
- 4 mL plastic pipettes
- several 20 mL calibrated capped jars or tubes
- 500 mL wash bottle
- plastic measuring cylinder
- Merckoquant test strips for nitrate, phosphorus, potassium and calcium.

Optional equipment:

- Nitrachek meter for more accurate reading of the nitrate test strips

Or, preferably

- Merck RQflex meter for accurate reading of the nitrate, phosphorus, potassium, calcium (and manganese if required) test strips.

Procedure

1. Collect a random sample of 30 leaf petioles (leaf stalks) from different plants. Remember to sample by mid morning and to keep each variety as a separate sample.
2. Cut the petioles into small segments about 2 mm long.
3. Using the garlic press, squeeze sap into the plastic capped tube.
4. Mix the sap thoroughly.

Nitrate and calcium tests

5. Add 1 mL of the sap to the 20 mL calibrated jar and make up to the 20 mL mark with distilled water. Mix thoroughly.
6. Briefly immerse each strip.
7. Read the concentration.
8. Multiply by 20 to get the concentration in the undiluted sap.

Potassium and phosphorus

9. Pipette 1 mL of the sap from step 4 into another jar.
10. Use a pipette to add 4 mL of distilled water.
11. Mix thoroughly.
12. Briefly immerse each strip.
13. Read the concentration.
14. Multiply by 5 to get the concentration in the undiluted sap.

Optimum sap levels for tomatoes

Table 16 shows the optimum sap levels for a tomato crop grown in southern Queensland. Sap nutrient levels for north Queensland should be a little lower than the south Queensland levels.

These levels can be affected by over or under watering and stressful conditions. Diagnose the cause of the low levels, then apply a suitable nutrient if necessary.

Table 16. *Optimum sap levels for nitrogen and potassium in southern Queensland*

Nutrient	Level in milligrams per kilogram (mg/kg, ppm)			
	Up to first fruit set	Early fruit fill	Late fruit fill to first harvest	During harvest
Nitrate	4 500 – 5 500	3 000 – 4 000	2 000 – 3 000	400 – 2 000
Potassium	4 000 – 5 000	4 000 – 5 000	4 000 – 5 000	3 500 – 5 000

Figure 6 is a diagrammatic representation of optimum nitrogen and potassium sap levels at various stages of plant growth.

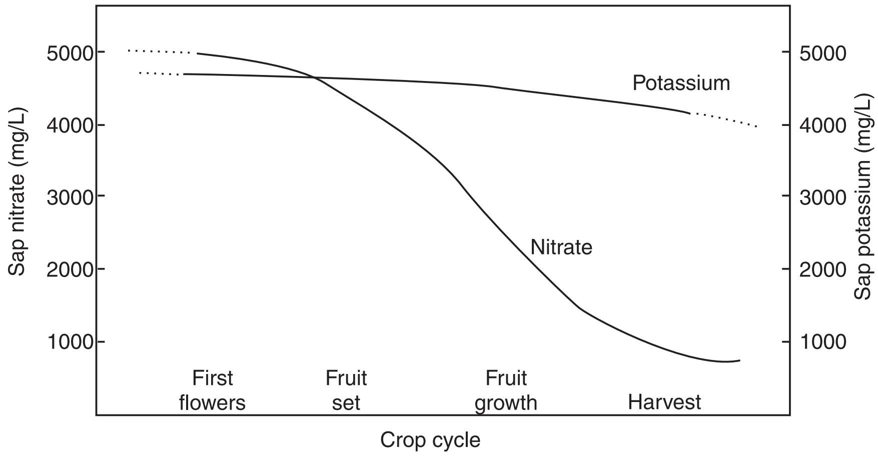


Figure 6. *Optimum sap nitrate and potassium levels in petioles*

Irrigation and water management

Irrigation management is one of the keys to producing a high yielding, good quality tomato crop. An efficient irrigation system and schedule is essential to ensure that the correct quantity of water is applied when the plants need it.

Water management to produce quality tomatoes

Table 17 shows the symptoms of poor water management at different growth stages.

Table 17. *The symptoms of poor water management in tomatoes*

Growth stage	Amount of water	
	Not enough water	**Too much water**
Early growth to budding	Poor growth Poor uptake of nitrogen and calcium Small plant	Leaching base fertiliser Root diseases, e.g. *Pythium, Rhizoctonia* Lush growth Poor flowering Shallow root system
Flowering to early fruit set	Small plants Low calcium and nitrogen uptake Falling flowers Termination of plant	Excessive vegetative growth, low flower set, poor uptake of calcium, phosphate and zinc Poor butt set Shallow root development
Late fruit set to fruit fill	Small fruit size Dropping flowers Blossom-end rot (BER) Small plant Sunburn	Poor fruit set Excessive vine growth Blossom-end rot (BER) Poor flesh structure due to low calcium balance Sudden wilt disease
Maturity to harvest	Small fruit Early maturity of fruit Blossom-end rot (BER) Sunburn Low yields	Blossom-end rot (BER) Poor keeping quality Low sugars Slow to mature Soft fruit Fruit susceptible to weather marking Sudden wilt disease

The main control method for producing high qualty tomatoes is accurate irrigation scheduling because inaccurate irrigation is the major cause of poor nutrition. Monitoring irrigation and nutrition gives you the best chance to achieve maximum profits. Most growers tend to over water in the early stages of the crop. This leaches fertiliser, in particular nitrogen, from the root zone and fertiliser is wasted.

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. Consult an irrigation equipment supplier or designer in your area and get them to develop an irrigation plan.

Irrigation methods

Trickle irrigation is the best and most common method of irrigation used in tomatoes, but furrow and overhead irrigation are sometimes used.

Trickle irrigation

Trickle irrigation is the most easily controlled method of irrigation. The equipment is expensive, but has a long life. If trickle tubing is to be re-used it should be treated with chlorine to reduce the risk of blockages. Soluble fertiliser mixtures and some pesticides can be applied easily through the irrigation system. Use a trickle tube with outlets no more than 20 cm apart. Table 18 shows the advantages and disadvantages of trickle irrigation.

Table 18. *Advantages and disadvantages of trickle irrigation*

Advantages	Disadvantages
Does not wet plants and wash off sprays	Requires a greater intensity of management
Easy to regulate applications	Requires regular maintenance during the growing period
Can apply small amounts often, (daily if necessary) in the critical period	High initial cost
Only wets the root area	Can block up if good filters are not used
Can grow crop on plastic mulch	Not suitable for steeply undulating country due to variable output
Can apply nutrients through the system	Susceptible to damage by crickets
Not affected by wind	Must take precautions to filter water and/or treat it for iron bacteria
Uses less water than other systems	
Can use poorer quality water than overhead systems	
Cheaper pumping costs because it requires low pressure	
Increases yields	

Furrow irrigation

Furrow irrigation requires an even, gentle slope and a soil type which allows water to spread laterally, without penetrating too deep into the soil. Table 19 shows the advantages and disadvantages of furrow irrigation.

Table 19. *Advantages and disadvantages of furrow irrigation*

Advantages	Disadvantages
Cheap to set up and operate	High water use
Does not wash spray off plants	Can cause heavy losses from fruit rots
Not affected by wind	Often have wet row ends and waterlogging
Can use poorer quality water than for overhead irrigation	Cannot apply fertilisers with irrigation
	Must have level ground
	Can result in erosion if slope is too steep
	Cannot use plastic mulch

Overhead irrigation

Overhead irrigation includes travelling irrigators or sprinkler systems. Overhead irrigation is suitable for any soil type and undulating country. Table 20 shows the advantages and disadvantages of overhead irrigation.

Table 20. *Advantages and disadvantages of overhead irrigation*

Advantages	Disadvantages
Easier than furrow irrigation to regulate water application	Washes spray off plants
Can be used in most situations	Expensive to set up
Can be used to reduce losses from frost	Affected by wind
	Wets interrow and headland areas, promoting weed growth
	Difficult to apply regular, small amounts
	High pumping costs because it requires high pressure, particularly for travelling irrigators
	Cannot use plastic mulch
	High water use
	Must use high quality water
	Cannot apply fertilisers with irrigation

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, that is a monitoring or scheduling system. The importance of monitoring is confirmed by research which shows that water use can be considerably reduced by monitoring without affecting yield and fruit quality. It also makes sure you are applying enough water at the critical times.

A range of equipment and techniques is available for monitoring soil moisture and scheduling irrigation. The most common are the soil-based systems using tensiometers, neutron soil moisture probes, or soil capacitance systems such as the Enviroscan. The other technique sometimes used is a climate-based system that uses estimates of evapotranspiration. The tensiometer or capacitance systems are preferred and recommended. A brief comparison of the main systems is shown in Table 21.

As soil moisture monitoring can be complex, seek expert advice first, particularly when setting up the system.

Table 21. *Comparison of the main soil moisture monitoring systems*

System	Advantages	Disadvantages
Tensiometers	• Relatively cheap • Easy to install • Can be read by growers • Continuous monitoring	• Labour intensive to collect and record data • Require regular maintenance • Can be inaccurate in extremely wet or dry soil
Capacitance probe e. g. Enviroscan	• Continuous monitoring • Accurate at all depths and for all soils • Enables rapid reading and recording of results	• Expensive • Need skill in interpreting data
Neutron probe	• Portable; can be moved around sites	• Not suitable for continuous monitoring • Equipment is expensive and radioactive. Use a consultant who owns the equipment • Less accurate in the top 10 cm of soil • Less accurate in sandy soil because of low sampling frequency
Evaporation pan	• No in-field measurement needed as system uses weather data to predict irrigation need	• Inaccurate as system ignores soil variability

Getting the best from your irrigation

To get the best from your irrigation system use a scheduling device, such as tensiometers, to help you make decisions about when to irrigate and how much water to apply. Remember that pesticide applications, irrigation systems, labour, the availability of water, and disease risk, all influence your decision to irrigate.

A strategy for irrigating tomatoes

Establishment. Ensure adequate moisture near the surface for a good strike and for the plant to begin to access the basal fertiliser application.

Flowering. After successful establishment let the soil dry out slightly from the surface to encourage root development down to 30 to 50 cm, which allows roots to access a larger volume of soil nutrients and moisture. As the plant goes into the reproductive stage, flower set is enhanced by a lack of abundant moisture.

Fruit filling. Once fruit have set, maintain soil moisture near the full point (field capacity) by not allowing the crop to take more than 50 to 70% of the available moisture. This facilitates fruit sizing and filling, which is a physiological response from the plant to maximise cell elongation when soil moisture is easily accessible.

Harvest. As harvest approaches allow soil moisture to decline to the refill point. This drying process helps in the development of sugars and other products in the fruit, improves final quality (flavour and firmness) and reduces breakdown of the flesh. This results ultimately in a more marketable product.

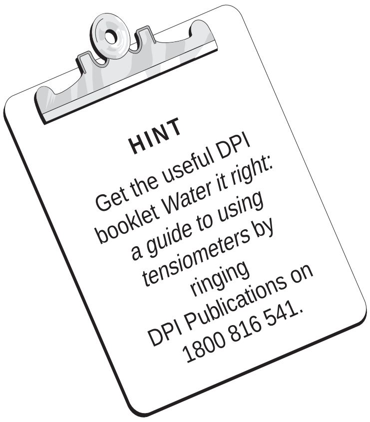
Tables 22 and 23 show the suggested readings for the shallow tensiometer (20 cm) for the different stages of plant growth.

Table 22. *Suggested shallow tensiometer readings from planting to early fruit set*

Soil type	Tensiometer reading	
	Establishment	**Up to early fruit set**
Sandy loams	10 – 25	10 – 30
Clay soils	10 – 30	20 – 35

Table 23. *Suggested shallow tensiometer readings from early fruit set through harvest*

Soil type	Tensiometer reading	
	Early fruit set to first harvest	**During harvest**
Sandy loams	10 – 25	15 – 30
Clay soils	10 – 30	15 – 35



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 centibars (kiloPascals or kPa) (Figure 7). In wet soil, the vacuum gauge displays 0 to 5 units kPa. 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. When the soil is re-wet after rain or irrigation, water moves from the soil back into the tensiometer and gauge readings fall.

A monitoring site consists of one shallow tensiometer (a) installed in the major root zone, and one deep tensiometer (b) below most of the roots (Figure 8). A crop planting should have at lease two monitoring sites. Shallow tensiometers should be placed within 10 cm of the crop row and midway between plants, though this can vary slightly. Install the shallow tensiometer with the tip 20 cm below ground and the deep tensiometer 45 cm deep. Install tensiometers after the crop is established, disturbing the plants and surrounding soil as little as possible.

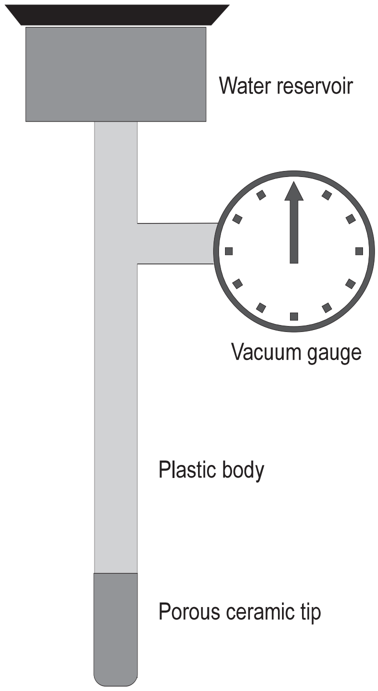


Figure 7. *Parts of a standard tensiometer*

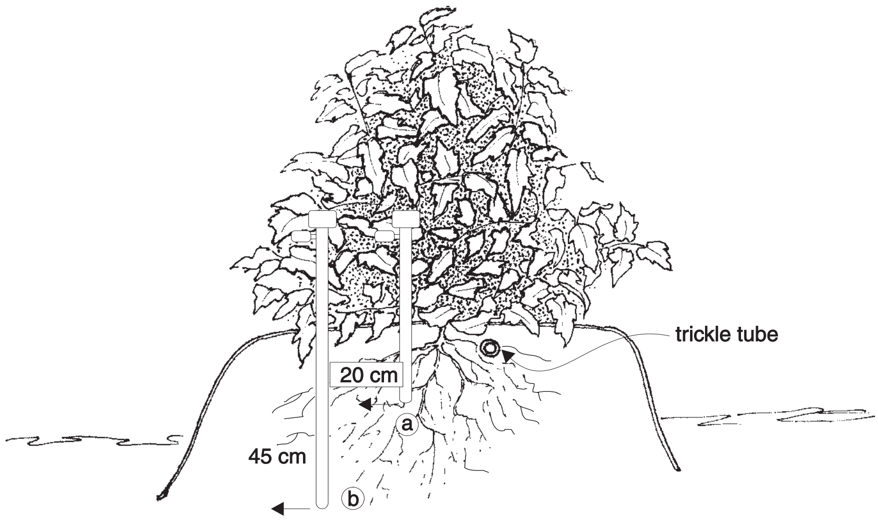


Figure 8. *Profile of a typical tensiometer monitoring site in tomatoes*

The shallow tensiometer (a) indicates when to water. The deep tensiometer (b) indicates when the right amount of water has been applied. If deep tensiometer readings fall to less than 10 kPa within two days after irrigation, there is more water than the root zone can hold. Constant values after irrigation indicate the root zone is saturated. If readings continue to rise immediately after irrigation, not enough water has been added to the root zone.

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 be pushed 20 cm into the soil. 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 be an expensive lesson. If you reach a hard soil layer, either take the tensiometer out and try somewhere else, or use the deep tensiometer procedure below.

To install the deep tensiometer, dig a hole 45 cm deep, keeping the excavated soil nearby in a pile. We have found a 50 mm (2 inch) auger the best tool. Put 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 most 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 over compact 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 once 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, causing 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 easier 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 and rainfall.

Clearly mark tensiometer locations, otherwise they may be damaged by tractors, harvesters, rotary hoes and other machinery.

Reading

Read tensiometers at the same time early in the morning, preferably before 8.00 a.m. because at that time there is little movement of water in the soil or plants and they are almost in equilibrium. Errors caused by heating of the gauge or water column are also avoided. Read at least twice a week, but preferably every one to two days. Lightly tap the gauge before reading.

It is a good idea to plot the daily readings on a chart. This will show what has happened in the past, for example when the crop was irrigated and whether it affected the deep tensiometer. By extending the line on the chart it can be used to predict when the next irrigation will be needed. Figure 9 shows diagrammatically how the tensiometer reacts to different amounts of irrigation while Figure 10 is a sample chart with shallow and deep tensiometer readings plotted over several irrigations. Use the following points when reading Figure 9.

A. Shortly after a good irrigation.
B. By extending the line from A through B, you can predict when an irrigation will be needed.
C. Just before irrigation.
D. After an irrigation which did not penetrate adequately.
E. Soil dried sooner because of inadequate irrigation.
F. Reflects an adequate irrigation following E.
G. It is helpful to show the date and hours of irrigation.

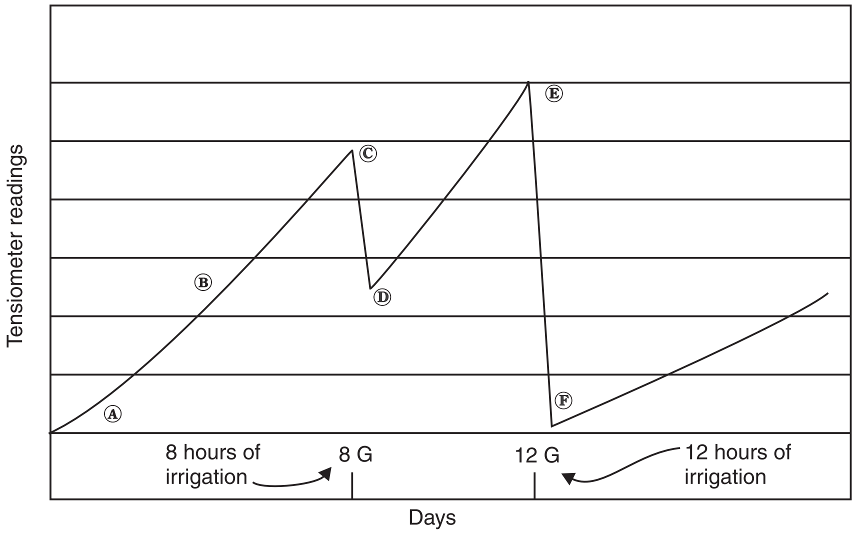


Figure 9. *Diagrammatic representation of tensiometer reaction to different amounts of irrigation*

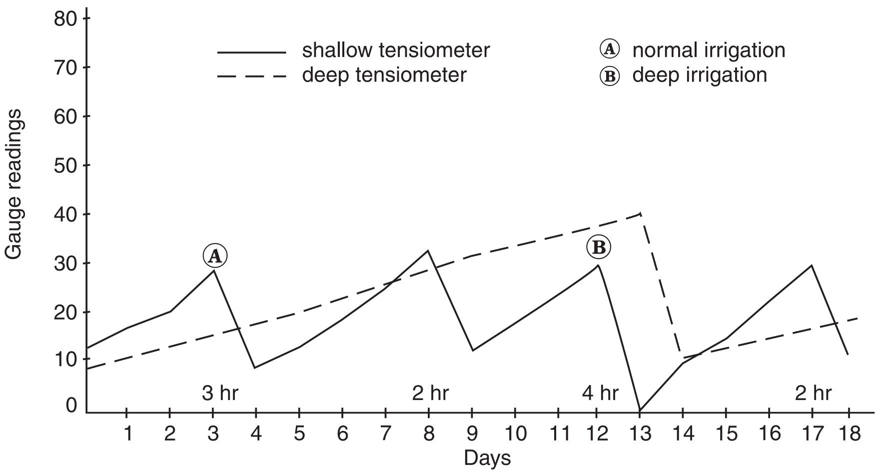


Figure 10. *A sample chart showing tensiometer readings plotted daily*

Maintaining tensiometers

Ensure that the water level is topped up regularly in the tensiometer. It is best to do this after an irrigation when the water level should not be more than 3 to 5 cm below the gauge. It will probably be more than this just before an irrigation is due.

Use a vacuum pump to remove air bubbles if the water level was very low. After removal from the soil, protect the tip of the tensiometer from dry air until it has been emptied, cleaned and dried.

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 more than 5

There is either a hairline crack in the tip, or a substantial air gap in the soil around the tip. Remove the tensiometer. 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 that the gauge is working.

- Apply suction to the tensiometer with a vacuum pump.

Or

- Remove the gauge, rinse with clean water and suck 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.

Getting started with tensiometers

A good grower starter pack would include two 30 cm and two 60 cm tensiometers, a suitable vacuum pump, algaecide and a one-metre long 50 mm diameter auger. The total cost should be less than $600. The best tensiometers have replaceable tips, gauges and reservoirs.

Tensiometers should be installed at two monitoring sites in a crop. Continue usual irrigation practices and get a feel for how tensiometers operate. Once you are comfortable with using them, make slight changes to your irrigation and observe what happens. For example, if the reading of the deep tensiometer always fall after irrigation, reduce the amount of water you apply.

Tensiometers are easiest to use in overhead irrigated vegetables; flood, furrow and drip irrigation systems are more complex because positioning of the tensiometer is more critical.

The Enviroscan capacitance probe

The Enviroscan 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 in the soil after the crop is established. The probes and tubes are left in place until the end of the season. 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 are downloaded to a computer every day or every few days and are available for viewing or printing within minutes. Figure 11 shows the main components of an Enviroscan probe.

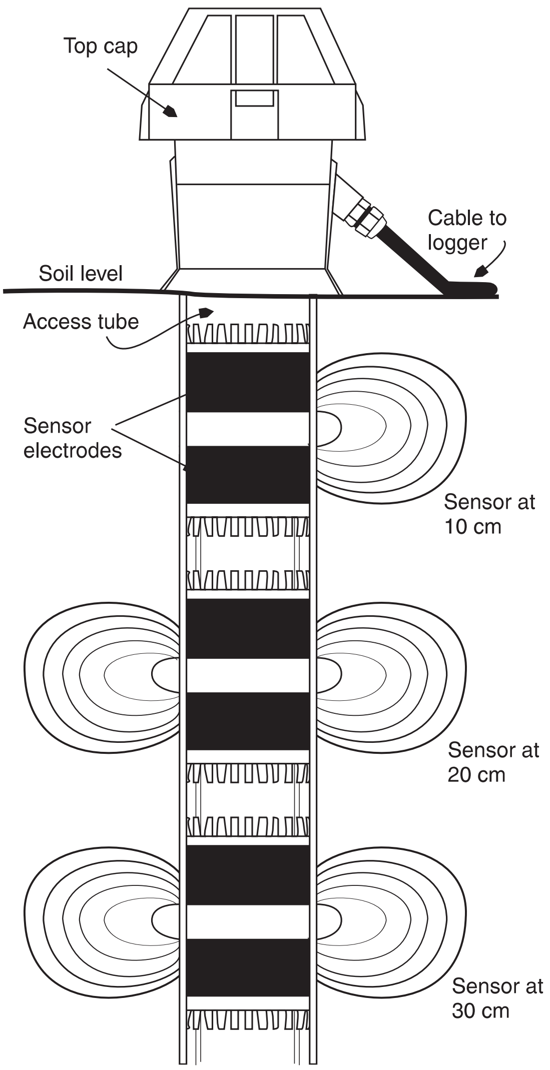


Figure 11. *Diagrammatic representation of an Enviroscan probe*

After downloading, the computer analyses the data and provides an accurate and dynamic understanding of the crop's daily water requirements and the effectiveness of irrigation and rainfall.

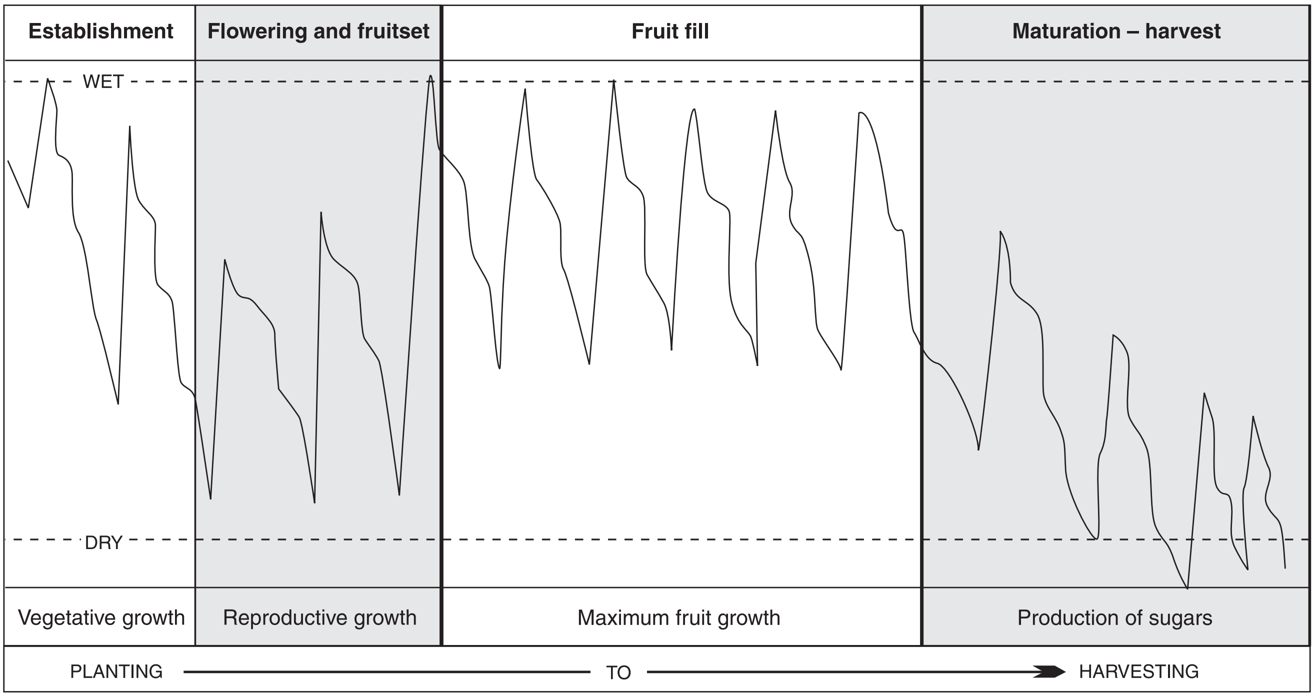
Access to this information removes the guesswork from irrigation decisions and provides a basis for further manipulation of the crop in areas such as flower set, fruit filling and fruit quality.

For tomatoes, two probes are recommended for a block of plants but the number of sites depends on the variability in soil and varieties. The probes should have sensors at 10, 20, 30 and 50 cm.

The current cost of a logger, solar panel, 100 m of cable, two 50 cm probes, eight sensors and software is about $5000 to $6000. Equipment can also be hired from some consultants.

more info
Irrigation consultants
Section 6 page 11

The interpretation of the data requires skill and we recommend that consultants are used to set up the system and provide at least the initial advice. Figure 12 is a diagrammatic representation of the water use of a tomato crop recorded by an Enviroscan. The high points occur after irrigation or rainfall.



Source: John Hall, Crop Tech

Figure 12. *A diagrammatic representation of irrigation and water use of a tomato crop as recorded by the Enviroscan*

Maintenance of a trickle irrigation system

Before developing your irrigation system, you should have your water tested to make sure that it is suitable for your crop and to check if it contains soluble iron. Iron bacteria in the water can turn the soluble ferrous iron into insoluble ferric iron that precipitates out of solution as a red sludge. This sludge will block the trickle outlets. Iron levels above 1 mg/L can cause problems. Chlorinating your water will kill the bacteria and so prevent the precipitation.

Filters

The outlets of trickle irrigation tape are very small, so a good filtration system is essential. There are three main types of filters: sand filters, mesh and screen filters, and multi-media filters. The type of filter you need will depend on the quality of your water. You should talk to a reputable irrigation specialist before deciding the type of filter you need.

The filters should be cleaned regularly, either manually or automatically. You should also flush out your pipes regularly; the dirtier your water, the more often you need to do it. Fit flushing valves to the ends of your trickle tubing so that the system is automatically flushed each irrigation.

Chlorination

Chlorination is an effective way of cleaning and keeping trickle tape clean by oxidising and destroying organic matter and micro-organisms. The quantity of chlorine required to oxidise these organisms is referred to as the chlorine demand of the water. The chlorine left after oxidisation is the residual chlorine which can be measured at the end of the irrigation system using a swimming pool test kit. You should aim to have 1 mg/L (ppm) chlorine at the end of your system so that you know you have used enough chlorine. The amount of chlorine required will depend on the quality of your water.

Chlorine is corrosive and toxic, so read the label carefully and handle it with care. It is available as liquid sodium hypochlorite, usually around 10 to 12.5% chlorine, or granular calcium hypochlorite, usually around 65 to 70% chlorine.

Chlorination can be:

- a continuous process using 1 mg/L residual chlorine
- a regular treatment at about 10 mg/L
- a slug dose using 500 to 1000 mg/L.

Test the water at the end of the system to ensure there is about 1 mg/L residual chlorine.

When using chlorine regularly it is injected over the last 20 to 30 minutes of an irrigation.

The slug dose is only used if the trickle outlets are badly blocked or before used tape is to be re-used. Chlorine at this concentration may damage plants. It is left in the system for 24 hours, then flushed out of the system. First flush water out of the mainlines, then the sub-mains and finally through the open the ends of the trickle tubing. If the mains and sub-mains are not flushed first, all the sediment cleaned from them will go into the trickle lines.

Chlorine can be injected into the irrigation water on either the suction or the discharge side of the pump, but before the filter. The filter must be resistant to corrosion by chlorine. Make sure the pump runs long enough after you stop injecting chlorine to ensure that no chlorine is left in the pump or any other metal part of the system.

Calculating how much chlorine to inject

To calculate how much chlorine to inject you need to know:

- the chlorine concentration of your chlorine product
- the flow rate of your pump in litres per minute
- how long it takes the water to reach the furthest point of your system.

Table 24 shows the amount of two chlorine products required to make two concentrations of chlorine.

Table 24. *Chlorine product required for two concentrations of chlorine*

Concentration required	12.5% chlorine product		65% chlorine product	
	rate per 100 L	rate per 500 L	rate per 100 L	rate per 500 L
10 mg/L	8 mL	40 mL	1.5 g	7.5 g
500 mg/L	400 mL	2 L	75 g	375 g

If your pumping rate is 500 L per minute, you will need to add each minute the amount required for 500 L, for as long as it takes the water to reach the furthest point of your system. You can use a swimming pool test kit to determine when the chlorine has reached this point.

An integrated approach to pest and disease management in the field

Managing pests and diseases is probably the most difficult aspect of growing tomatoes. Serious pests and diseases will most likely be a problem at some stage in the life of the crop. These problems have the potential to reduce fruit yield and quality and therefore profit. This section describes an integrated approach to pest and disease management which takes account of prevailing conditions and suggests more sustainable methods of tomato production.

Introduction

The traditional approach to pest control is to apply regular routine sprays of chemicals, for example spraying by the calendar. This approach has several problems.

Cost. It is costly, with many sprays being applied each season, even if there are no pests in the crop.

Plant tolerance. Even when pests are present, it disregards the fact that plants can tolerate small numbers without significantly affecting yield and quality. In these cases, the cost of spraying is much greater than the benefit gained by controlling the pest.

New chemicals. It relies heavily on new chemicals being developed to replace those for which insects and diseases develop resistance. The reality is fewer new chemicals are being discovered and developed.

Exposure. It exposes the farm family and employees to a range of toxic chemicals and increases chemical residues in the fruit and the environment.

Other problems. It induces some problems such as spider mites.

Integrated Pest Management

The modern approach to crop protection is to manage the pests with a range of control methods so that they do not cause economic damage. Heavy spraying to destroy all pests is neither efficient nor desirable. Unsuitable pesticides may even create pest problems by killing the parasites and predators of other insects.

Integrated Pest Management (IPM) is the preferred approach to crop protection because it uses cultural, biological and chemical measures to manage tomato pests and diseases. Integrated Pest Management involves the following techniques and decisions:

- farm hygiene
- selecting the right site
- selecting your production method
- selecting your production period
- selecting the right variety
- monitoring (bug checking)
- making a pest management decision
- introducing parasites and predators.

Farm hygiene

Poor farm hygiene will result in losses from pests and diseases. Good farm hygiene is one of the simplest and most often overlooked method of pest management. It results in fewer pests and diseases developing on and being spread around the farm. Good farm hygiene includes these management practices.

Crop rotation. Don't plant tomatoes after tomatoes, capsicums, egg fruit or potatoes.

Cover cropping. These crops improve the soil's structure and its water and nutrient-holding capacity.

Land preparation. Good land preparation assists plant establishment and reduces the risk of waterlogging and plant losses from damping-off and other soil-borne diseases.

Destruction of old crop residues and weeds. Destroy old crop residues, weeds and volunteer (self-set) plants that are a reservoir of pests and diseases. Plough in crops as soon as harvesting is completed.

Removal of reject fruit. Remove and destroy reject fruit that can be a source of infection by crushing fruit in and around the field and crushing and burying rejects from the packing shed.

Good hygiene. Apply a high standard of hygiene and quarantine in the field and the packing shed.

Selecting the right site

Select a site that does not have a history of problems, or the problems that have occurred are more common in a different season. Remember that:

- bacterial wilt may be severe in a block in the warmer months but cause little production loss in winter
- losses caused by nematodes are more likely in sandy soils
- frost damage is more likely in lower areas and where air flow is restricted.

Selecting your production method

You may choose to grow your crop on the ground, on a trellis or under cover using trickle, overhead or furrow irrigation. All of these methods can have an influence on what pests and diseases occur. Remember that:

- ground crops are more prone to ground rots of fruit
- mites can cause serious losses in crops grown under cover
- overhead irrigation can wash sprays off the plant.

Selecting your production period

The time of year will influence what problems you have with your crop. Select a production period that will minimise pests and diseases. Remember that:

- foliage diseases are usually worse in warm, wet weather
- sclerotinia rot occurs in winter
- heliothis and potato moth (leafminer, potato tuber moth) are usually worse in warm weather
- mites prefer warm, dry conditions.

Selecting the right variety

a key issue
Varieties
This section page 16

The variety you choose will be determined by your production method, time of production and known or expected problems. Refer to the variety descriptions for disease tolerance or resistance, plant type and preferred conditions.

Monitoring (bug checking)

Monitoring tomatoes for pests and diseases is the first step in the crop protection cycle. Without monitoring you have no evidence of what

more info
Horticultural consultants
Section 6 page 4

pest management strategies need to be carried out or how well your current pest management strategies are working.

We recommend you use a competent pest consultant to do the monitoring for you. If you do not hire a professional bug checker we suggest that you get some training from a pest consultant. There are a few procedures to follow in doing your own monitoring. Ideally, inspections should begin in the nursery and continue until the end of harvesting. The intensity of monitoring will vary with the crop stage, pest pressures and the weather conditions.

What you will need to monitor a crop

You will need:

- a monitoring log book; (A sample page that you can photocopy is on page 61.)
- a 10 power hand lens; (Most optometrists stock these.)
- plastic freezer bags to keep samples of pests unknown to you for identification.

more info
Problem solver
Section 5

It is not necessary to be able to identify all the problems you find but the more you can identify the better.

How to monitor a crop

1. Set aside enough time to check a block carefully.
2. Know what you are looking for in general terms before going out to the block.
3. Look in the most likely places in the bush for each particular pest or disease.
4. Check each area or block regularly, twice a week in summer, once a week in winter.
5. Check a good cross section of the block; pests can often be in patches or at one end or side of a block.
6. Write down what you find in a proper monitoring log or a diary.
7. Simple tables and graphs of data help define patterns and maps help identify local problems and pest movement.

more info
Pest and disease monitoring
This section page 60

Don't worry about not seeing a particular problem — you will. Unhealthy plants quickly catch your eye as you walk through a block. Initially, you will probably find a lot of suspect plants but not be able to identify the problem.

If a plant doesn't look healthy and you don't know why, put it in a plastic bag and have somebody identify it for you. Department of Primary Industries extension staff or local bug checkers provide this service. A small 10 power hand lens assists with viewing small insects. Soon you will be skilled at identifying the range of pests and diseases that occur on your farm.

Pest and disease monitoring

The following is one of several procedures that can be used for pest and disease monitoring as indicated in Step 3 of *How to monitor a crop* (this section, page 59).

Check overall appearance of the plants, paying attention to variations in colour and vigour. Yellowing patches should be inspected closely for mite infestation, waterlogging or heavy disease infection.

Look for wilted or yellowing plants and examine these for symptoms of disease or physical damage. In summer, *Sclerotium rolfsii*, *Pythium*, bacterial or fusarium wilt and sudden wilt are common while *Sclerotinia*, *Botrytis* and verticillium wilt are common winter problems.

Examine at least 10 and preferably 20 average plants thoroughly. These plants should be selected at random as you walk through the block. Carefully note and record the following information:

- The number of Heliothis eggs on the top three growing shoots, five flowers and one hand of early set fruit. Remove mature flowers to check for small larvae on the developing fruit.
- The presence of any diseases on the top third of the mature bush or the whole plant on young crops.
- The number of aphids, Rutherglen bugs or other sucking pests on the top third of the bush.
- Note the presence of the various diseases on the bottom two-thirds of the bush.
- The number of leaves showing mite damage.
- Remove one, full sized mature leaf that touches the ground and count the potato moth larvae.
- The presence or absence of stem bronzing indicating russet mite damage.
- Note any other symptoms on the plant.
- Look around layflat hoses, hydrants, filters or other objects where spray coverage may be poor to see if any pests are present.
- Weed types and stages of growth, and if they are harbouring insect pests or diseases.
- Check around the block for possible sources of reinfestation.
- The number of moths and fruit flies in the various pheromone traps.

Record all observations in the monitoring log.

Tomato pest and disease monitoring log

Block: ______________________________ Date: ______________

Weather since last monitored: ______________________________

Use the following code to determine what to check: # = number counted; P = presence; S = symptoms; D = plant death

	Insects and mites							Disease								Comments
Code	#	#	P	S	#	#	#	P	P	P	P	D	D	P	P	
Sample	Heliothis	Potato moth	Twospotted mite	Russet mite	Aphid	Rutherglen bug	Fruit fly	Target spot	Bacterial spot	Grey mould	Leaf mould	Sclerotinia rot	Base rot	Virus	Big bud	
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																
13																
14																
15																
16																
17																
18																
19																
20																
Total																
Average																
Trapped																

Thresholds from planting to early fruit set

Pest	No. of plants to check	Part of plant to check	Record	Average number per plant Low	Medium	High
Insects and mites						
Heliothis	10 – 20	Whole plant	No. of eggs No. of larvae	0 – 2 0 – 0.1	3 – 10 0.1 – 0.5	10+ 0.6+
Potato moth	10 – 20	Lower leaves	Larvae	0 – 0.1	0.1 – 0.5	0.6+
Twospotted mites	10 – 20	Lower leaves	Presence	0	1 – 2	3+
Russet mites	10 – 20	Stem	Symptoms	0	1 – 2	3+
Aphids	10 – 20	Whole plant	Nymphs + adults	0 – 0.1	1 – 5	5+
Rutherglen bug	10 – 20	Whole plant	Nymphs + adults	0 – 1	1 – 3	4+
Diseases						
Target spot	10 – 20	Whole plant	Presence & activity	0 – 1	2 – 4	5+
Bacterial spot	10 – 20	Whole plant	Presence & activity	0 – 1	2 – 4	5+
Grey mould (*Botrytis*)	100 m of row	Whole plant	Presence & activity	0	1 – 2	2+
Leaf mould	10 – 20	All plants	Presence & activity	0 – 1	2 – 5	6+
Sclerotinia rot	100 m of row	All plants	Plant deaths	0 – 1	2 – 4	4+
Base rot (*Sclerotium*)	100 m of row	All plants	Plant deaths	0 – 1	2 – 4	4+
Virus	100 m of row	All plants	Presence	0 – 1	2 – 4	4+
Big bud	100 m of row	All plants	Presence	0 – 1	2 – 4	4+

Source: John Hall, Crop Tech Research

Thresholds from fruit set to harvest

Pest	No. of plants to check	Part of plant to check	Record	Average number per plant Low	Medium	High
Insects and mites						
Heliothis	10 – 20	3 terminals + 5 flowers + 1 hand of early set fruit	No. of eggs No. of larvae	0 – 2 0 – 0.1	3 – 10 0.1 – 0.5	10+ 0.6+
Potato moth	10 – 20	3 lower leaves	Larvae	0 – 0.1	0.1 – 0.5	0.6+
Twospotted mites	10 – 20	3 lower leaves + 1 middle leaf	Presence	0	1 – 2	3+
Russet mites	10 – 20	Stem + 3 lower leaves	Symptoms	0	1 – 2	3+
Aphids	10 – 20	3 lower leaves + 3 terminals	Nymphs + adults	0 – 0.1	1 – 5	5+
Rutherglen bug	10 – 20	Whole plant	Nymphs + adults	0 – 1	1 – 3	4+
Fruit fly	10 – 20	Whole plant + traps	Larvae + adults	0	0 – 2	2+
Diseases						
Target spot	10 – 20	Whole plant	Presence & activity	0 – 1	2 – 4	5+
Bacterial spot	10 – 20	Whole plant	Presence & activity	0 – 1	2 – 4	5+
Grey mould (*Botrytis*)	100 m of row	Whole plant	Presence & activity	0	1 – 2	2+
Leaf mould	10 – 20	All plants	Presence & activity	0 – 1	2 – 5	6+
Sclerotinia rot	100 m of row	All plants	Plant deaths	0 – 1	2 – 4	4+
Base rot (*Sclerotium*)	100 m of row	All plants	Plant deaths	0 – 1	2 – 4	4+
Virus	100 m of row	All plants	Presence	0 – 1	2 – 4	4+
Big bud	100 m of row	All plants	Presence	0 – 1	2 – 4	4+

Source: John Hall, Crop Tech Research

Making a pest management decision

The first decision you must make is whether management actions, including pesticide applications, are needed to avoid losses from pest damage. The management of pests in your tomatoes depends on you making the right management action decisions. You should aim to:

- introduce parasites and predators (beneficials) if suitable ones are available
- spray only when the pest level becomes economically damaging
- spray at the stage in the pest life cycle when it is most susceptible
- spray the affected plants or parts of the plant, not the whole crop
- use sprays that will be least damaging to beneficials.

Monitoring and thresholds help you make these decisions. A threshold is the critical level at which a decision is made and is often referred to as an action threshold. Below this threshold you maintain as many cultural practices as possible to reduce the pest or disease impact on your tomatoes, and above which you start specific control measures targeted at the pest. The thresholds are based on the average number of pests found per plant.

$$\text{Threshold} = \frac{\text{total number of pests recorded}}{\text{number of plants inspected}}$$

Use the broad pest and disease thresholds on page 62 as a guide in making decisions to actively target a pest. With experience you may be able to refine these thresholds for your situation.

Thresholds for insect pests are generally based on the pest numbers and stages found in the crop by monitoring. They are intended to reflect the pest level that will cause economic damage. If pest pressure is high you will be over the threshold, if it is low you won't reach the threshold.

Thresholds for other pests are normally based on the block history, stage of development of the crop, weather conditions and other observations. Record all these in your monitoring log as they can be used to judge when outbreaks may occur.

Tomatoes are so susceptible to root-knot nematodes under Queensland conditions that control measures are normally recommended if **any** nematodes are found on a previous crop or any root-knot nematodes are found in soil samples taken before planting.

When pest pressure is likely to be high or the crop is at a sensitive stage to that pest, use the **low** threshold figure as a guide to when specific action should be taken.

When pest pressure is likely to be low or the tomato crop can tolerate the pest, use the **high** threshold figure as a guide to when specific action should be taken. During other times use the **medium** threshold figures as a guide to when specific action should be taken.

A review of the variations recorded in pest levels is another guide to making the decision to act.

a key issue

Calibrating a boom spray
This section page 84

An increase in pest activity may indicate the need for:

- checking application equipment
- a different pest control strategy
- a different pesticide selection
- an additional pest control strategy
- a shorter spray interval.

A decrease in pest activity may indicate the need for:

- a longer spray interval
- a softer pesticide selection
- reduced targeting of that pest.

You can now decide which specific pests to control by comparing your monitoring log to the thresholds.

HINT
The Problem solver handy guide in the front of this kit lists the registered pesticides for use in tomatoes.

Once you have decided what pests need to be targeted, you are ready to decide what control actions to use. As well as pesticides, other pest management strategies such as field hygiene and quarantine, biological control, variety resistance and crop rotation should be incorporated into the pest management plan. The use of a range of these pest management options in an integrated approach is called Integrated Pest Management (IPM). IPM generally reduces the risk of crop loss because it uses a broad range of options rather than relying on a single control option.

Biological controls

Biological agents (beneficials) can be used to manage some pests of tomatoes, however, growers can not depend entirely on natural or released beneficials, particularly for Heliothis. They may be insect parasites or predators of pests, or bacteria or viruses that infect the pest. Nature provides many beneficials in our fields, for example spiders and wasps. Some beneficials are reared commercially and can be released into the crop, for example *Trichogramma* wasps, lacewings and predatory mites. Others are available as sprays, for example *Bacillus thuringiensis*.

more info

Suppliers of beneficials
Section 6 page 7

While beneficials are expensive, they remove the cost of chemical applications and avoid the risk of pests developing resistance to the chemical controls. However, it is difficult to base pest control on beneficial insects because of the high level of chemical application that can be necessary in tomato production. If possible avoid using pesticides which may kill the beneficial insects. The suppliers of the predators and parasites will also provide a list of chemicals which will not affect them.

Beneficial insects and mites

Beneficial insects which help control pests may be either parasites or predators. Parasites include *Trichogramma* wasps, which lay their eggs in Heliothis eggs which are then killed by the wasp larvae, and the *Copidosoma* wasp that lays its eggs in potato moth eggs. *Orgilus* wasps lay their eggs in potato moth larvae.

Predators include predatory mites that eat twospotted mites and lacewings that eat a range of insect pests.

Handle parasites and predators very carefully and follow the supplier's instructions.

Bacillus thuringiensis (Bt)

Bacillus thuringiensis is a bacterial biological insecticide used to control Heliothis larvae (tomato grub) and potato moth in tomatoes. *Bts* are applied as a spray and produce a toxin that affects the gut of the larvae. Table 25 shows some of the advantages and disadvantages of *B. thuringiensis*-based products.

Table 25. *Advantages and disadvantages of Bts*

Advantages	Disadvantages
Only affects caterpillars, does not harm beneficials.	May take some days before the larvae are killed, though it will stop feeding well before that.
Reduces the risk of resistance developing to other chemical controls.	Short persistence. *Bts* are deactivated by sunlight.
Soft on beneficial insects so is useful in IPM programs.	Expensive.

Pest management in the field

Insect and mite infestations are a major cause of losses in yield and quality in tomatoes. Monitoring for insects and mites and controlling them is critical to your success as a tomato grower. The main problems are Heliothis, potato moth, twospotted mites and tomato russet mites.

Heliothis (tomato grub, corn earworm, budworm)

more info
Pictures of tomato pests
Problem solver

Heliothis grubs are the larvae of *Helicoverpa armigera* and *H. punctigera* and are the key insect pests of tomatoes. Management of Heliothis will influence the management of many other pests. Heliothis will be present throughout the year, with more in warmer months and few in cold areas in winter.

Heliothis moths can travel over long distances, both between and within districts and regions. On-farm control must be constant as moths can move in from a wide area to reinfest the crop.

There is a very low tolerance for Heliothis damage in tomatoes so the action thresholds are very low. While biological agents may help in the management of Heliothis, insecticides are usually needed to obtain commercially acceptable levels of control. Treatments should be aimed at eggs or very young larvae.

Monitoring

Monitor crops frequently so that you can make good treatment decisions. Check the top of the plant, flowers and flower trusses. Crops should be checked more frequently in warm weather as insects, including Heliothis, develop faster under these conditions.

Control of Heliothis

Heliothis may be controlled by biological means, chemical insecticides or a combination of these methods. Biological controls may be beneficial insects or sprays of *Bacillus thuringiensis* (*Bt*), a bacterial biological insecticide.

Beneficial insects

Although Heliothis eggs and larvae are attacked by many parasites and predators, they normally do not provide a sufficient level of control.

The egg parasite, *Trichogramma* (a wasp), occurs naturally and can destroy many eggs. *Trichogramma* are also available commercially and can be released into crops as a natural 'insecticide' to increase the percentage of eggs parasitised. This technology is still experimental, so growers should be cautious. Releases of these wasps may be useful when Heliothis pressure is low or before crops are fruiting. They are susceptible to most chemical insecticides. Follow the supplier's instructions and treat the *Trichogramma* wasps with care as they are delicate insects.

Bacillus thuringiensis (*Bt*)

Bts are reasonably effective against Heliothis, however, their use may result in a high level of pinhole damage in fruit as the larvae must feed to obtain a dose of *Bt*. *Bt* may be most useful when Heliothis pressure is low, or early or late in the life of the crop.

Insecticides

Insecticides are usually needed to control Heliothis and a range of insecticides is registered for this purpose. Some insecticides kill only larvae while others kill both eggs and larvae.

H. armigera has developed resistance to a range of insecticides in several chemical groups. These insecticides may no longer be effective.

Good coverage is important. On trellised crops most eggs are laid on the upper half of the plant, so take particular care with coverage of this part of the plant. Timing of sprays is important. Eggs and young larvae are much easier to kill and do less damage than older larvae.

HINT

The Problem solver handy guide (in the front of this kit) lists chemicals registered to control Heliothis.

Potato moth (leafminer, potato tuber moth)

Potato moth, *Phthorimaea operculella*, is another important pest which causes considerable damage when it attacks fruit. Populations of potato moth are higher in late spring, summer and through to mid-autumn than in winter, though in mild climates they occur all year. The moths do not travel the great distances that Heliothis moths do, so infestations tend to be more localised.

Monitoring

Moth numbers can be monitored using pheromone traps which attract the males. These traps will indicate whether pest numbers are high or low and so give an indication of whether infestations are likely to occur in the field. They may also indicate an invasion of moths from a particular direction and identify parts of the crop that need extra checking. Larval mines can be monitored in leaves.

Control of potato moth

Potato moth can be controlled by cultural or biological means, chemical insecticides or, more commonly, a combination of these methods.

Production breaks

Potato moth numbers and hence problems will be reduced if there is a break between successive host crops (tomatoes, potatoes, tobacco and egg plant). Capsicums are very poor hosts of potato moth, but they are occasionally damaged. The break can be in time, by separating crops by several months, or in space by separating successive crops by a considerable distance. Production breaks require cooperation of all growers of all host crops within a region.

Hygiene

Hygiene is very important in potato moth management. Old tomato crops should be desiccated, (for example with paraquat or glyphosate), pulled down and the plant residues ploughed in as soon as possible after harvest so that potato moth cannot continue to breed in or emerge from the old crops. The same applies to other host crops and in particular to discarded potato tubers and volunteer plants. Potato moth will develop in some Solanaceous weeds including thornapples, ground cherry and Devils fig, so remove these weeds. Take care not to introduce potato moth into fields by planting infested seedlings.

Biological management

more info
Beneficial suppliers
Section 6 page 7

Several wasp parasites (*Orgilus*, *Apanteles* and *Copidosoma)* attack potato moth. Although they infest young larvae and eggs of the potato moth, they allow the larvae to develop to maturity before they kill it. The larvae will still damage fruit, but numbers in the next generation are reduced.

The parasites are susceptible to many of the insecticides used in tomatoes. Predators (ants, predatory beetles and possibly spiders) may also be important in potato moth management.

Bacillus thuringiensis (*Bt*) sprays will kill some larvae and their use preserves beneficials, which then contribute to the control of larvae.

HINT
The *Problem solver* handy guide in the front of this kit lists chemicals registered to control potato moth.

The Bt must be eaten by the larvae, so larvae feeding in mines are protected from the *Bt* on the leaf surface as they will not eat a dose of it.

Insecticides

Potato moth appears to have developed resistance to many insecticides previously used to control it because many of them are no longer effective. Spray coverage is important. In trellised crops potato moth infestations will be heaviest near the ground, so target this area.

Mites

Mites are usually more of a problem in warm dry conditions and can cause serious problems in crops grown under cover, for example plastic houses.

Spider mites (twospotted mites)

Spider mites, usually twospotted mite *Tetranychus urticae* or sometimes the bean spider mite *Tetranychus ludeni*, infest a wide range of plants. They cause a yellow stippling of the upper surface of the leaf and a fine webbing under the leaf. They can also cause blotchy ripening of fruit. Spider mites are worst in warm dry conditions and can be spread by wind and carried on clothing, machinery, birds and insects. They can also cause problems by making some workers itchy.

Monitoring

Monitor for mites by looking for the yellow stippling on the upper surface of leaves and checking the under surface for mites with your hand lens.

Control of spider mites

Spider mites can be very difficult to control in warm, dry conditions. It is important that you monitor the crop and take action as early as possible to prevent a major flare-up of mites. Hygiene, predators and miticides are all options that should be considered.

Hygiene

Clean up old crops immediately after harvest and remove weeds and volunteer hosts from around the crop. Check seedlings to make sure you are not bringing infested plants onto your property.

Predators

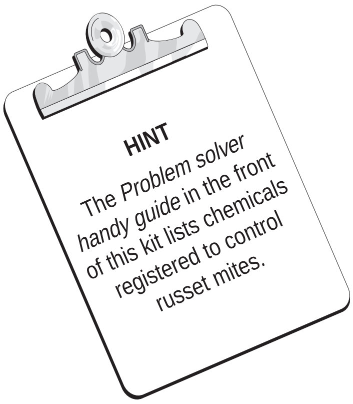
more info
Predatory mite suppliers
Section 6 page 7

Predatory mites can be purchased to control spider mites, however, many of the chemical insecticides used to control other pests will also kill these predators. The companies supplying predatory mites will supply a list of chemicals that are least harmful to the predators. Releasing predators into the headlands around new plantings may help reduce mite numbers before they move into the crop.

Miticides

There are chemical miticides registered to control spider mites, however, mites are able to develop resistance to these chemicals fairly quickly, particularly if the same miticide is used too regularly. Some chemicals, particularly pyrethroids, kill predators and can lead to a rapid build up of mites. Good coverage of the under side of leaves is essential for the chemicals to be effective.

Russet mites



Russet mites (*Aculops lycopersici)* are worst in hot dry conditions, from spring to autumn in north Queensland and late spring to autumn in south Queensland. They are spread by wind and carried on clothing, machinery and insects. Feeding causes the loss of plant hairs, bronzing of the plant stems and death of lower leaves, as well as blotchy ripening of fruit. Severe infestations will kill plants.

Monitoring

Russet mites are very small and difficult to see even with a 10 power hand lens. They build up on the lower part of the plant on the stem, then move onto leaves and fruit. Look on the stems, particularly near the leaf axils. The first symptoms of damage will be the collapse of the fine hairs on the plant stem. This is followed by a bronzing of the stem and death of lower leaves.

Control of russet mites

Russet mites can be very difficult to control in warm, dry conditions. It is important that you monitor the crop and take action as early as possible to prevent a major flare-up of mites. There are no biological methods available to control these mites, hygiene and miticides are the only options.

Hygiene

Clean up old crops immediately after harvest and remove weeds and volunteer hosts from around the crop. Check seedlings to make sure you are not bringing infested plants onto your property.

Miticides

Apply a miticide as soon as the threshold is reached or numbers may build up rapidly in warm dry conditions. Good coverage of stems and the under side of leaves is essential for the chemicals to be effective.

Disease management in the field

Congratulations! You have chosen the vegetable crop which has more recorded diseases than any other in Queensland. Disease monitoring and control is critical to your success as a tomato grower. Particular diseases will vary in their importance from region to region. Foliar diseases will increase in severity with more frequent rainfall.

Correct diagnosis is the key to successful disease management, but this is not always easy since different diseases can have similar symptoms.

Soil-borne diseases

more info

Pictures of tomato diseases
Problem solver

Fungal and bacterial wilts

Fungal and bacterial wilts will occur in the same field year after year and will spread with soil or water movement. They are well adapted to survive for long periods in the soil and can be carried to new areas in contaminated soil on implements, stakes and posts.

Symptoms include discoloured roots and internal stem tissues, stunting, leaf yellowing, wilting and death. They are caused by two soil fungi and a bacterium. The fungal wilt diseases are fusarium and verticillium wilts while the disease caused by the bacterium is bacterial wilt. Verticillium and bacterial wilt are more common in south-east Queensland.

Bacterial canker can also cause serious problems in some years. It is usually introduced in seed and survives on weed hosts, for example nightshade and for short periods in the soil on undecomposed crop residue. It is spread in sap during transplanting, trellising and pruning.

a key issue
Varieties
This section page 16

Management comes down to three choices.

Resistant varieties are available for fusarium wilt races 1, 2 and 3; Verticillium wilt race 1 and bacterial wilt. Note that there is no resistance available for Verticillium wilt race 2, which is common in south-east Queensland. Resistant varieties are strongly recommended for control of fusarium wilt race 3.

Fumigation with methyl bromide (while still available) or metham sodium will reduce the severity of fungal wilts.

Rotation with non-host crops and **hygiene** measures to prevent introduction to your property or between fields should be introduced before these problems appear.

Integration of the three approaches will give best results.

Hints on the diagnosis of wilt diseases

Fusarium wilt. Leaves turn yellow, starting at the base; reddish discolouration of internal stem tissues.

Verticillium wilt. Lower leaves turn blotchy yellow; internal stem tissues only slightly off-white, stunting, low vigour.

Bacterial wilt. Rapid wilting, leaves wilt but remain green; internal stem tissues brown.

Bacterial canker. Leaves sometimes show one-sided wilting; cavities develop in the pith tissue near leaf nodes. White, birds-eye spots appear on fruit.

Root-knot nematodes

HINT

Some laboratories will test soil and root samples for nematodes. See Contacts page 7.

Root-knot nematodes are more common on light sandy soils rather than heavy or compacted soils. Damage is more severe in warmer months. The root-knot nematode causes galls on roots which disrupt water and nutrient supply to the plant, leading to poor growth.

Rotations with non-host crops or a fallow period of one year will reduce nematode populations. If your property has a history of root-knot, a soil test will indicate whether you should be using a nematicide, for example Nemacur. Recent research has shown organic mulches (sawdust, manure, sugarcane residues) suppress nematode activity.

Monitor for nematodes

Monitor the roots of broadleaf weeds before the final cultivation. Monitor for nematodes at the end of a crop to give you an indication of the need for nematode control measures in your **next** tomato crop.

A thorough sampling of a block at the end of the crop will provide more information than simply having soils analysed for nematodes before planting the next crop.

The following is a technique for sampling nematodes.

- Dig up plants from several areas of the block, taking care to retrieve the fine feeder roots.
- Carefully examine all roots for the presence of galls.
- The number and size of galls provides an indication of the degree of root-knot nematode infestation.

more info
Testing for nematodes
Section 6 page 7

Foliar diseases

Fungal and bacterial

The severity of leaf diseases will vary with weather conditions and age of the crop.

Target spot is a major fungal disease of tomatoes. It is spread by wind, rain and overhead irrigation. Target spot is worse in warm, wet weather and in winter when there are heavy dews and fogs. Brown leaf spots with concentric rings develop first on lower leaves and progressively move up the plant.

Bacterial spot and **bacterial speck** cause dark, greasy spots mainly on young foliage. The bacteria survive on crop residues in soil, on volunteer plants and weeds. They can also be seed-borne. In dry conditions these two bacterial diseases are unimportant. However, explosive outbreaks can occur in wet periods when the bacteria are spread by wind in water droplets, overhead irrigation and on machinery and pickers hands. Damage is particularly severe if foliage has been injured by hail or strong winds. Flowers and fruit can also be affected.

Control of these three diseases is essential. Although some tomato varieties are less susceptible to target spot than others, all varieties should be monitored or included in a regular protectant spray program. Crops grown with a well managed fertiliser and irrigation program will generally be less prone to damage.

Leaf mould can be a problem in warm humid weather. It survives in the soil and on crop residue. The spores — the olive green fungal growth on the leaf spots — are spread by wind.

In monitored crops, fungicide application can be delayed until first sign of disease. In other crops, a regular program must start 7 to 10 days after transplanting into the field.

Chemical control

Copper fungicides (copper hydroxide, copper oxychloride, cuprous oxide) are the only products available to protect tomatoes against bacterial diseases. They also give reasonable control of target spot provided disease pressure is low to moderate.

Fungicides like mancozeb, Antracol, chlorothalonil and Polyram are more effective against target spot. All these fungicides prevent spore

> **HINT**
> For an anti-resistance strategy for systemic chemicals for these diseases, refer to this section page 76.

germination. They are not systemic. Regular applications (7 to 10 days) are needed to protect new growth. Under high disease pressure a combination of a copper fungicide with either chlorothalonil, mancozeb, Antracol or Polyram is recommended. During wet weather, reduce the spray interval as disease activity is higher and fungicide deposits are washed from the plant. Rovral has some systemic activity against target spot and can be used strategically. Regular use is not recommended as this may lead to resistance in both target spot and grey mould.

Remember, target spot, bacterial spot and bacterial speck are carried over on trash. Destroy old crop residues quickly.

Hints on diagnosis of foliage diseases

Target spot. Brown spots with concentric rings, more severe on older leaves.

Bacterial spot and speck. These cannot be reliably distinguished in the field. Small spots (specks) on young foliage; larger dead areas around leaf margins and damaged tissue; greasy appearance.

Spotted wilt virus. Brown blotches and spots on leaves and fruit can be confused with target spot. Leaf stalks bend downwards.

Stemphylium leaf spot. Small angular pale spots; only occurs on lines which do not have resistance.

Diseases caused by viruses

The most common virus diseases are tobacco mosaic virus, spotted wilt, leaf shrivel and yellow top. They show a variety of symptoms including stunting, leaf mottles and distortions as well as uneven colour and spots in fruit. All contribute to low yields.

Virus diseases are spread with plant sap. All virus diseases of tomato are found in other crops or weeds which serve as virus reservoirs. Management depends on eliminating weed reservoirs, hygiene during planting and handling plants, and controlling insect vectors. Table 26 shows how the viruses are spread and possible sources of infection.

Table 26. *How viruses are spread and possible sources of infection*

Virus	How spread	Source
Mosaic	By hands, on trellis wires, stakes and posts and machinery, or plant contact.	Solanaceous weeds (e.g. night shade, cape gooseberries)
Spotted wilt	Thrips	A large range of crops (e.g. lettuce) and weeds (e.g. milk thistle)
Leaf shrivel	Aphids	Capsicum, apple of Peru, night shade, cape gooseberries
Yellow top	Aphids	Thornapple, apple of Peru, night shade, shepherd’s purse

Hints on diagnosis of viral diseases

Mosaic. A mosaic pattern of light green-dark green on leaves.

Spotted wilt. Purplish-brown spots scattered irregularly on young foliage and stems and fruit, down-turning of leaves, ring spots in fruit.

Leaf shrivel. Leaflets have a clawed appearance with mottling. Older leaves are spotted on the undersurface and die prematurely.

Yellow top. Tops of plants are stiff and yellowish. Leaves are smaller than normal.

Fruit problems

Surface blemishes

Surface blemishes, cracks and blotches on fruit are due to:

- foliage diseases transferring to fruit (target spot, bacterial spot and speck)
- viral diseases (spotted wilt, mosaic)
- insect activity (twospotted mite and russet mite)
- cold, wet, windy weather
- shading of fruit due to bushy foliage or extended overcast weather
- a fungus (*Stemphylium* spp.) is often associated with small surface cracks in the skin of tomato fruit.

Soft rots

Soft rots are due to:

- *Sclerotinia* and *Botrytis* fungi
- yeasty rot (*Geotrichum* fungus)
- bacterial soft rot.

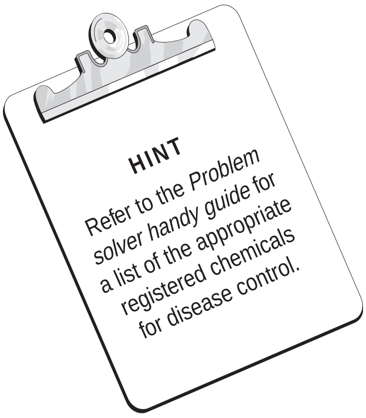
Problem management

Any of the above disease, insect or environmental problems can cause big reductions in marketable yield. All are very dependent on weather conditions.

Management of surface blemishes and blotches depends on controlling the fungal, bacterial and insect causal agents during the growth of the crop. Excessive nitrogen results in bushy crops and uneven ripening of fruit which develop in the centre of the bush.

The soft rots caused by *Sclerotinia* and *Botrytis* fungi occur with cool moist weather. They survive in the soil as hard sclerotes and on undecomposed crop residue. Spores are spread by wind. *Sclerotinia* and *Botrytis* fungi also attack stems and flower trusses causing light coloured (bleached) dead sections. Fruit usually becomes infected through the stalk or where an infected leaf or petal touches it. *Botrytis* (grey mould) develops a thick grey whiskery growth during humid conditions. Breakdown of fruit is rapid once fruit starts to colour. *Botrytis* especially can be an important postharvest problem.

Yeasty rot and bacterial soft rot usually occur in fruit harvested during wet weather. They are spread in water during harvesting and packing. Management of these rots is a combination of hygiene and a fungicide for yeasty rot and chlorine for bacterial soft rot. *Botrytis* can move between sequential plantings, so early crop destruction is essential. Crop monitoring from flowering will determine the need for a special fungicide program to control sclerotinia rot and grey mould.



For sclerotinia rot, use benomyl, iprodione or procymidone. *Botrytis* has strains resistant to all these fungicides. We recommend:

- a spray program based on chlorothalonil for low infestation
- alternating chlorothalonil with iprodione (Rovral) or procymidone (Sumisclex) for moderate infestation
- combining chlorothalonil with either Rovral or Sumisclex for severe disease infestation.

Management of geotrichum fruit rot depends on avoiding wet weather harvests if possible and treating fruit with chlorine at 50 milligrams per litre (mg/L, ppm) or guazatine. Treatment must be applied as soon as possible after harvest.

Resistance to systemic fungicides

Target spot and grey mould can both become resistant to the highly active systemic chemicals used to control them. The following strategies are designed to reduce the risk of resistance becoming a problem.

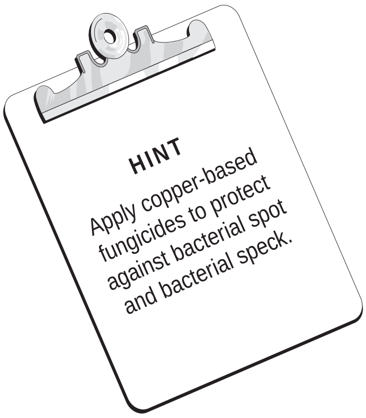
Target spot

more info
Application rates
Problem solver handy guide

Resistance is less likely to develop if Group B fungicides are used strategically in a program with Group Y fungicides. Table 27 lists the two activity groups of fungicides for target spot control.

Table 27. *The activity groups of fungicides for control of target spot*

Group B (dicarboximide) systemics	**Group Y (multi-site activity)** protectants
iprodione	chlorothalonil
	copper hydroxide
	copper oxychloride
	cuprous oxide
	mancozeb
	metiram
	propineb
	zineb



a key issue
Calibrating a boom spray
This section page 84

Use the following strategy to reduce the risk of target spot resistance to systemic fungicides.

1. Ensure that spray application equipment is well maintained, properly set up and calibrated to give good spray coverage.
2. Spray at 7 to 14 day intervals with a protectant fungicide from group Y.
3. Monitor for target spot. If the incidence is increasing or continuous moist conditions favourable to target spot occur, apply a systemic fungicide from group B. Where high disease pressures are encountered, apply tank mixes of a protectant and a systemic. Use a maximum of three systemic sprays per crop.
4. When monitoring indicates a reduction in disease pressure, drop systemic fungicides from the spray program until needed again.

Grey mould (*Botrytis*) and *Sclerotinia*

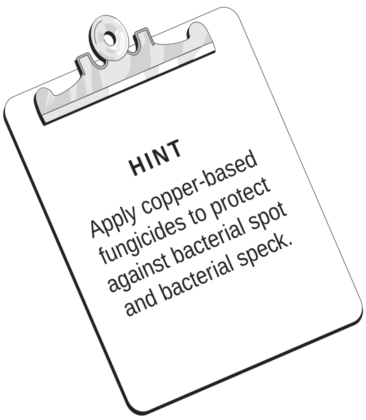
Grey mould is normally not a problem until flowering. For *Sclerotinia*, use benomyl, iprodione or procymidone. *Botrytis* has strains resistant to all these fungicides. Resistance is less likely to develop if Group A and B fungicides are used strategically in a program with protectant fungicides Groups X and Y. Table 28 shows the four activity groups of fungicides for control of grey mould.

Table 28. *The four activity groups of fungicides for control of grey mould*

Group A (benzimidazole)	Group B (dicarboximide)	Group X (unspecified)	Group Y (multi-site activity)
systemics		**protectants**	
benomyl	iprodione procymidone	dichlofluanid	chlorothalonil

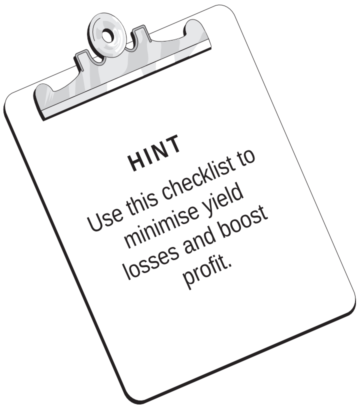
Use the following strategy to reduce the risk of grey mould developing resistance to systemic fungicides.

1. Ensure that spray application equipment is well maintained, properly set up and calibrated to give good spray coverage.
2. Spray with chlorothalonil or dichlofluanid at the first appearance of the disease or when conditions become favourable, and repeat at seven to 14 day intervals into the picking season.
3. Monitor for grey mould and if the incidence is increasing start alternating systemic fungicides from groups A or B. (Note that in some districts high resistance already exists to benomyl.) Where high disease pressures are encountered tank mixes of chlorothalonil or dichlofluanid and a systemic can be applied.
4. When monitoring indicates a reduction in disease pressure, drop systemic fungicides from the spray program until needed again.



Benomyl and dichlofluanid do not control target spot.

Disease control program check list



Pre-planting

- ❍ All old crops on farm turned in.
- ❍ Nematode assay required.
- ❍ All crop residues have rotted down in proposed tomato field.
- ❍ Fumigate before planting if previous history indicates fumigation may be necessary.
- ❍ Virus weed hosts destroyed.
- ❍ Spray gear checked (new nozzles) and calibrated.
- ❍ The tomato variety selected has resistance to wilt or virus diseases present.
- ❍ The seed has been acid-extracted or had hot water and trisodium phosphate treatments.

Establishment

- ❍ Seedlings are disease-free and not leggy.
- ❍ Monitor for transplanting losses.

Early growth

- ❍ Be prepared to start spray program.
- ❍ Monitor for foliar diseases and insect vectors of virus.
- ❍ Monitor fertiliser and irrigation for steady crop growth.

Fruit set

- ❍ Increase surveillance of foliar diseases; reduce spray interval in wet conditions.
- ❍ Check for first signs of *Botrytis* and *Sclerotinia*.
- ❍ Maintain steady crop growth without heavy top development.

Harvesting

- ❍ Maintain foliar disease control program; pay attention to the chemical withholding period.
- ❍ Monitor for *Botrytis* in field; change spray program if necessary.
- ❍ Monitor fruit for postharvest problems, dip if necessary.
- ❍ Note position of any wilt-affected areas and determine cause.

Crop end

- ❍ Look at roots for signs of root-knot nematodes.
- ❍ Plough in.
- ❍ Clean trash from wires before rolling.
- ❍ Sterilise wires by spraying or dipping in a chlorine or quaternary ammonia-based compound.

Seed treatment

Seed is normally extracted from the fruit using hydrochloric acid (HCl). Seed which has been acid-extracted will be free from tobacco mosaic virus and surface-borne bacterial canker, bacterial spot, bacterial speck and target spot. To control internal seed infections you need to hot-water treat your seed at 55°C for 25 minutes. To control tobacco mosaic virus, soak the seed in trisodium phosphate.

Hot water treatment

Commercial laboratories will treat seed for you or you can do it yourself. You will need this equipment to treat small quantities (up to 100 g) of seed:

- an accurate thermometer (0 to 60°C, calibrated in half degrees)
- electric frypan
- large saucepan
- fine mesh kitchen sieve
- spoon
- clock
- absorbent paper tray.

To treat seed at 55°C, do a practice run of the method without seed to help the operator maintain a constant water temperature during seed treatment.

Warm the electric frypan. Add water (slightly above 55°C from a hot water system or electric jug) to a depth of 3 to 4 cm. Fill the saucepan two-thirds full of water at the same temperature. Stand the saucepan in the frypan on two pieces of wire about 2 mm in diameter to reduce the 'bottom heat' effect of the frypan during treatment. Gently stir the water in the saucepan with the spoon until the temperature drops to 55°C. When reading the thermometer, immerse the tip to half the depth of the water.

Heat the water to 55.5°C to allow for the drop in temperature when the seed is added. Pour the seed into the water and stir it with the spoon until it is wet. If some seed floats, stir more vigorously. For hard to wet seed add two drops of wetting agent (such as household detergent) to the water. Keep the seed in motion by gently stirring. Read the temperature and heat when necessary by turning up the thermostat switch of the frypan until the red light comes on, heating for five to 10 seconds, and then turning the thermostat switch down until the red light goes off. Repeat the procedure every one to two minutes or when the temperature drops below 55°C. If the temperature rises quickly and approaches 56°C, lift the saucepan and rest it on the frypan edge or add cold water until the temperature drops to 55°C. Maintain the water temperature at 55°C in this way until the recommended seed treatment time has elapsed.

When the hot water treatment is complete, pour the contents of the saucepan through the sieve and spread the seed on the absorbent paper tray, away from direct sunlight, until it is dry.

Points to remember

- Accurate control of temperature and time of immersion are critical. Excessive time and temperature may result in poor germination and the development of unthrifty seedlings.
- Store seed in muslin or paper bags (not in sealed tins or jars) and do not store for long periods. The shorter the storage period, the better. It is best to hot-water treat only the quantity of seed you intend to plant almost immediately.

Trisodium phosphate treatment

Seed that was not acid-extracted should be treated with trisodium phosphate (TSP) as follows:

- Soak the seed in a 10% solution of TSP for one hour after it has cooled down from the hot water treatment. Make sure the seed is thoroughly wet.
- After treatment, wash thoroughly in running water.
- Dry and store as for hot water treated seed.

Saving your own seed

Most tomato varieties now grown are hybrids and if seed from them is planted the resulting crop will vary a great deal. Growers can keep seed from open pollinated varieties and it will produce similar plants and fruit to the original. The best way to save seed is to use the acid extraction method which is fast and controls tobacco mosaic virus and disease organisms on the seed surface.

Acid extraction of seed

1. Cut ripe fruit and squeeze out the pulp.
2. Add 30 mL of hydrochloric acid (HCl) to 1 L of pulp and mix thoroughly.
3. Stir regularly over three hours.
4. Decant the liquid then thoroughly wash the seed in clean water.
5. Spread seed out to dry quickly but do not use artificial heat.
6. Store seed in a ventilated container in a cool dry place.

Postharvest pest and disease management

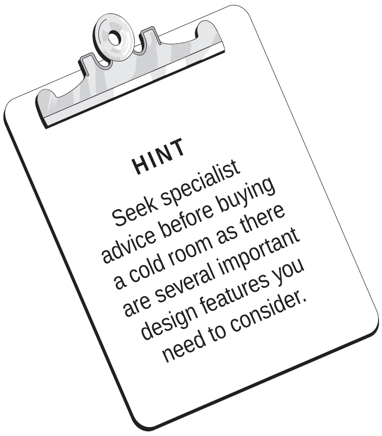
Careful handling and postharvest treatment of tomatoes is critical to ensure that you can put top quality fruit into the market place and be confident that it will not break down in the market chain.

Cooling

Pest and disease problems develop more slowly at low temperatures. Take fruit to the shed or place fruit in the shade as soon as possible after harvesting. After packing, cool fruit for transport to market. Table 29 lists suitable temperatures for cooling fruit before and during transport.

Table 29. *Temperatures for cooling fruit before and during transport*

Colour stage of fruit	Storage time	
	Less than 4 days	**More than 4 days**
Mature green (1)	13°C	13°C
¼ to ¾ colour (2 – 4)	7 – 10°C	10 – 13°C
Coloured to full colour (5 – 6)	5 – 7°C	7°C



The forced air cooling system is the fastest and most efficient. Using the forced air system ensures uniformity of cooling throughout as air is passed through the bulk bin or carton, giving rapid and equal cooling. The time taken to cool depends on the capacity of the equipment installed and the ventilation provided in each bin or carton. With forced air cooling a pallet of fruit would take about three to six hours to cool, with room cooling it could take over 24 hours.

Fruit colour will change very little if cooled fruit is held at the recommended temperature throughout holding and transport.

Chemical treatments to control postharvest rots

Fruit treatment

When fruit reaches the packing shed it is usually tipped into a hopper attached to the grader by a creep feed. Water is sprayed over the fruit to remove accumulated dust and to loosen other leaf debris that may be stuck to the fruit. In some of the bigger sheds fruit is emptied into a heated, chlorinated, water bath and floated to an elevator. The pH of the water must be adjusted to about 6.5 to 7.5 using a food-safe acidifier, for example acetic acid. At a pH above 7.5 it becomes less effective while below 6.5 pH the chlorine breaks down rapidly. The water must be warmer than the fruit to prevent rot organisms being absorbed with water through the stem scar into the fruit.

The fruit then passes over a series of roller brushes to remove adhering material such as soil and leaves. Near the end of the brushes use a spray jet system to apply a fungicide or a chlorine wash to the fruit. Chlorine should be applied within three hours of harvest for best effect, after this the rot organisms may have penetrated too far into the fruit to be controlled. Use a swimming pool test kit to regularly check the level of chlorine in the water and add more chlorine as it dissipates. Meters, for example redox meters, can also be used to check chlorine levels. If the water becomes dirty replace it to reduce fruit infection and staining.

more info
Postharvest treatments *Problem solver handy guide*

These chemical treatments are applied to control fruit breakdown throughout subsequent handling and marketing. This may be fungal breakdown, for example alternaria rot, grey mould, Rhizopus rot, transit rot and yeasty rot, or bacterial soft rot.

Use screens to separate the wash section of the equipment from the section applying the treatment, so that water does not dilute the mix. Insertion rubber slit into 25 mm strips is effective. A slower brush speed and using sponge rollers to absorb the water will also reduce dilution. Alternatively, do not recycle the fungicide.

Using chlorine to reduce infection

A 50 milligram per litre (mg/L, ppm) chlorine solution can be used to control infection. Sodium hypochlorite is available as a liquid containing from about 4% to 12.5% chlorine. To make a 50 mg/L chlorine solution, mix 40 mL of 12.5% sodium hypochlorite or 125 mL of 4% sodium hypochlorite in 100 L of water.

Sodium hypochlorite should be kept in its original container in a cool place out of direct sunlight as it decomposes rapidly.

Calcium hypochlorite (Hypochlor, Activ 8), chlorine dioxide (Oxine) and bromochlorodimethylhydantoin (Nylate) are alternatives to sodium hypochlorite.

Fruit fly treatment

more info
Fruit fly treatments
Growing the crop
page 62

Fruit fly infestation can also cause serious losses. Postharvest treatment is only required for some markets.

The postharvest treatment is applied as a dip or a flood spray and must be the last treatment applied. Your local DPI plant health inspector can give you up-to-date information on how to set up your equipment to meet the requirements of other states.

The chemicals used to control fruit fly are broken down by chlorine, so fruit must be dry and there can be no chlorine contamination of the fruit fly treatment.

Tasmania requires that treated fruit is packed into cartons with gauze screening to prevent reinfestation.

Shed hygiene

Clean shed equipment, cold rooms, picking equipment, etc. regularly to reduce the chance of fruit infection from these sources. Chlorine solutions are effective but corrode metal equipment and some rubber compounds. Quaternary ammonia compounds are also effective and non-corrosive.

How to calibrate a boom spray

To ensure good plant coverage by pesticides it is important that the spray equipment being used is calibrated to accurately apply the correct amount of chemical where it is needed. Most sprays fail because the chemical was not correctly applied.

Introduction

One method of calibrating a boom spray for ground crops and another for trellised crops is shown below. For a mature crop sprayed with a boom spray about 1000 L/ha is applied, however, much lower rates are used if misters or Micronair equipment are used.

These calibration methods are a guide to ensuring that the equipment is performing as it was designed. The equipment should initially be set up by someone who is experienced in setting up spray equipment for tomato spraying. They will help you select the type of equipment you need (the pump, diameter of hoses, type of nozzles) and the general setting up of the equipment to adequately protect your crop. The nozzles are usually set up so that the spray pattern overlaps the next nozzle by at least one third.

HINT
More information on calibrating spray equipment is available in the DPI's Pesticide application manual. To get this book refer to Section 6 page 20.

Before calibration, measure the output of each nozzle for a set time, for example 30 seconds, and discard any nozzle that varies more than 10% from the others. You need a good quality, oil-filled pressure gauge to get accurate pressure readings. When calibrating set the gauge at the pressure you will be using for spraying.

Ground crops

To calibrate a boom spray without droppers use the following method.

To find the volume of spray applied per hectare you need to know the total output of your nozzles and the time it takes to cover 1 ha, that is:

Volume per hectare = output x time to cover 1 ha

Step 1

Output = the total output of all nozzles

OR

Output = the average output multiplied by the number of nozzles

For example: If your spray rig has 20 nozzles (four spraying over each of five rows) with an average output of 3 L per minute, then:

Output per minute = 20 nozzles x 3 L /minute = 60 L /minute

Step 2

Calculate the effective spray width (swath) of the boom.

Swath width (m) = number of rows x row spacing (m)

For example: For 10 row lands you spray 5 rows at a time, so if they are 1.8 m apart, then:

Swath width (m) = 5 rows x 1.8 m = 9 m

Step 3

To determine the time to cover 1 ha you need to know the swath width (from Step 2) and the time to cover 100 m. Mark out 100 m and note how long it takes the tractor to travel 100 m in the gear and at the engine revolutions at which you will be spraying.

Step 4

$$\text{Time to spray 1 ha} = \frac{\text{10 000 (sq. m /ha) x time to cover 100 m}}{\text{swath width x 100}}$$

Divide this figure by 60 to get the time per hectare in minutes.

For example: If swath width = 9 m (from Step 2) and time per 100 m (Step 3) = 90 seconds, then:

$$\text{Time to spray 1 ha} = \frac{\text{10 000 sq. m x 90 seconds}}{\text{9 m x 100}} = \text{1000 seconds}$$

Divide this by 60 = 16.7 minutes per hectare

To work this out using a calculator: 10 000 x 90 = 900 000; divide by 9 = 100 000; divide by 100 = 1000 seconds; divide by 60 = 16.7 minutes per hectare.

Step 5

Volume of spray per hectare = output per minute (Step 1) x time in minutes to cover 1 ha (Step 4).

From the examples above:

Volume of spray per hectare = 60 L /minute x 16.7 minutes /ha

Volume /ha = 1002 L/ha

Trellised crops

The following example is for calibrating a spray rig for trellised tomatoes using a boom with droppers.

To find the volume of spray applied per hectare you need to know the total output of your nozzles and the time it takes to cover 1 ha, that is:

Volume per hectare = output x time to cover 1 ha

Step 1

Output = the total output of all nozzles

OR

Output = the average output multiplied by the number of nozzles

For example: If your spray rig has 39 nozzles (five spraying each side of the plant and one over the row), with an average output of 1.5 L per minute, then:

Output per minute = 39 nozzles x 1.5 L /minute = 58.5 L/minute

Step 2

The swath width is the number of rows sprayed multiplied by the distance between the rows.

For example: If you have seven row lands you spray three full rows and half of the fourth (centre) row with each pass (Figure 13).

If the row spacing is 1.8 m and you are spraying 3.5 rows

Swath width = 1.8 m x 3.5 rows = 6.3 m

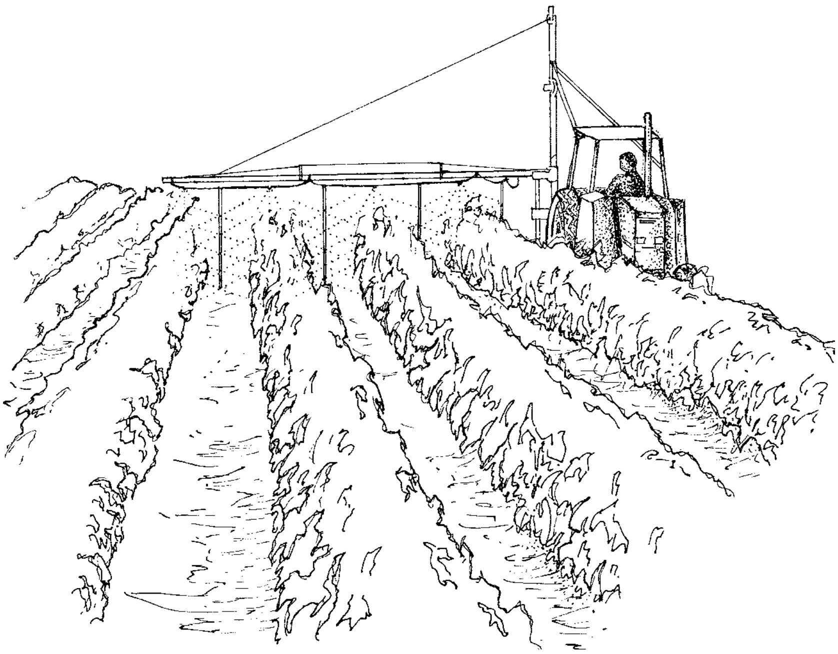


Figure 13. *A boom spray with droppers spraying a seven row land*

Step 3

To determine the time to cover 1 ha you need to know the swath width (from Step 2) and the time to cover 100 m. Mark out 100 m and note how long it takes the tractor to travel 100 m in the gear and at the engine revolutions at which you will be spraying.

Step 4

$$\text{Time to spray 1 ha} = \frac{\text{10 000 (sq. m /ha) x time to cover 100 m}}{\text{swath width x 100}}$$

Divide this figure by 60 to get the time per hectare in minutes.

For example: If swath width = 6.3 m (from Step 2) and time per 100 m (Step 3) = 65 seconds then:

$$\text{Time to spray 1 ha} = \frac{\text{10 000 sq. m x 65 seconds}}{\text{6.3 x 100}} = \text{1032 seconds}$$

Divide this by 60 = 17.2 minutes per hectare

To work this out using a calculator: 10 000 x 65 = 650 000; divide by 6.3 = 103 175; divide by 100 = 1032 seconds; divide by 60 = 17.2 minutes per hectare.

Step 5

Volume of spray per hectare = output per minute (Step 1) x time in minutes to cover 1 ha (Step 4).

From the examples above:

Volume of spray per hectare = 58.5 L /minute x 17.2 minutes /ha

Volume /ha = 1006 L/ha

Amount of chemical per tankful

For either calibration method the amount of product to put into the tank is determined by either:

$$\frac{\text{Tank capacity (L) x recommended rate of product (L/ha or kg/ha)}}{\text{application rate (L/ha)}}$$

For example:

$$\frac{\text{3000 (L) x 2 (L or kg/ha)}}{\text{1000 (L/ha)}} = \text{6 (L or kg)}$$

OR

$$\frac{\text{Tank capacity (L) x recommended rate of product (L or kg /100 L)}}{100}$$

For example:

$$\frac{\text{3000 (L) x 0.2 (L or kg/ 100 L)}}{100} = \text{6 (L or kg)}$$

Alternatives to methyl bromide

The continued use of methyl bromide, the main soil fumigant used in tomatoes, is under threat. There are many questions that are being asked about the future of methyl bromide and the alternatives that are available. Here are the main things you need to know.

The immediate problem with methyl bromide

You have probably heard about the problem with gases such as CFCs and halons attacking and breaking down the ozone layer in the atmosphere. The bromine from methyl bromide has also been shown to be a major destroyer of the ozone layer. There is a lot of concern about the destruction of the ozone layer as it will, amongst other things, increase the risk of skin cancer, particularly in countries like Australia.

As a result, Australia is part of an international effort to reduce bromine emissions. This is being implemented through Australia's involvement as one of 149 nations which are signatories to an international agreement called the *Montreal Protocol on Substances that Deplete the Ozone Layer*. Through this Protocol, it was agreed in 1995 to completely phase out the use of methyl bromide in Australia by 2005. This is being achieved by the Commonwealth Government progressively restricting import of methyl bromide over the period to 2005. The policy is being administered by the Federal Government agency, Environment Australia.

Pros and cons of methyl bromide

These are the main advantages of methyl bromide.

- It has provided a reliable and consistently effective soil treatment in a wide range of soil types and environments.
- Its broad spectrum of activity has enabled it to be used as an effective insurance against a wide range of diseases, pests and weeds.

- Specialised equipment makes it relatively easy to apply.
- It dissipates from soil relatively quickly so in warm, moist soil planting can be done as soon as three to four days after treatment.
- It produces what is known as 'a non-specific fumigation response' — a plant growth response which is often beneficial but is not well understood.

Besides its ozone depletion problem, methyl bromide has some other important problems.

- It may leak into groundwater. Methyl bromide has already been banned in The Netherlands because of this problem.
- Methyl bromide, because of its wide spectrum of activity, may also kill beneficial soil organisms including mycorrhiza. Although the short term effects of this may be minimal, the long term effects on the fertility and structure of soils are still largely unknown.
- As methyl bromide is a highly toxic and dangerous gas, it needs to be applied by experienced operators under carefully managed conditions.

Possible alternatives

The range of possible chemical and non-chemical alternatives for methyl bromide are listed in Tables 30 and 31. Some are practical alternatives, some are still highly theoretical and are only included to give a complete picture. Research is being done to assess alternatives.

Table 30. *Chemical alternatives to methyl bromide*

Chemical	Effective against			Current status
	Diseases	Nematodes	Weeds	
Metham, Metham Sodium	✔	✔	✔	Cheaper and easier to apply than methyl bromide. Effective but not as effective as methyl bromide. Requires more accurate placement or irrigation water to spread it through the soil. Limited by 2 to 3 week plant-back period. Most effective when applied under plastic sheeting.
Basamid	✔	✔	✔	Effective but very costly. Limited by 2 to 3 week plant-back period. Most effective when applied under plastic sheeting.
Chloropicrin	✔	✔		Excellent disease control but poor weed control. Limited by 6 week plant-back period. Has very objectionable odour. Sold only as a mix with methyl bromide.
Fungicides such as Ridomil, Chloroturf etc.	✔			Effective against some specific diseases but limited by cost, potential disease resistance and rapid degradation in soil.
Nematicides such as Nemacur, Rugby		✔		Effective against nematodes and some soil insects. Problems include high mammalian toxicity, potential to contaminate groundwater, and rapid degradation in soil.
Herbicides			✔	Problems include cost of application, and potential for crop damage.

Table 31. Non-chemical alternatives to methyl bromide

Treatment	Effective against			Current status
	Diseases	Nematodes	Weeds	
Steam/hot water	✔	✔	✔	Effective but cost seriously limits usefulness.
Soil solarisation	✔	✔	✔	Effective in some situations but limited by cost, climate and season.
Resistant varieties	✔	✔		Little known resistance in existing varieties. Best medium to long term solution.
Cultivation			✔	Limited application for weeds only.
Crop rotation	✔	✔	✔	Effective against some problems. Limited by amount of land available.
Organic treatments	✔	✔		Beneficial in improving soil fertility. Limited by cost, reliability and lack of information.
Biofumigation	✔	✔		Beneficial in improving soil fertility. Recent trials indicate some potential.
Biological control	✔	✔	✔	Specific to certain problems. Limited practical applications to date.
Artificial soil	✔	✔	✔	Limited to hydroponic systems.
Irradiation	✔	✔		Limited by practicability and cost.
Quarantine and use of clean planting material	✔	✔		Useful only against problems transported on planting material.

Tables 30 and 31 indicate that practical alternatives are limited at this stage. There is no other registered or existing chemical that has the same attributes as methyl bromide, so there is no easy shift to another chemical. Research indicates that a mixture of chloropicrin and another fumigant may be a practical solution to this problem. Some growers see metham as the only current alternative but it is doubtful if this represents a long term solution. The last 20 years has seen the demise of five or more fumigants — current ones may also go the same way.

Future strategies for the grower

Here are some suggestions as to strategies that may be worth considering.

Mixtures and application rates. In the short term while methyl bromide is being phased out, you may find that the 70:30 and 50:50 mixtures of methyl bromide and chloropicrin are as effective as methyl bromide alone. You might also like to experiment with reduced application rates, particularly if you are fumigating sandy soils or if your target is nematodes rather than fungal diseases. The use of less permeable plastic will also enable you to get the same result with less methyl bromide.

Why are you really using methyl bromide? This is a necessary question as methyl bromide has been widely used as a general insurance against a broad range of problems, in some cases even when the problem didn't exist. So go back to where you were before you started to use methyl bromide and identify your main target problems. You can then look most effectively at what alternatives there are.

Soil fertility. Think of your soil not as an inert medium to support the plants, but rather as a living fertile system in which soil bacteria, mycorrhiza, earthworms and other soil micro-organisms interact with nutrients and organic matter. This is important as no single approach will probably provide an effective alternative to methyl bromide. The answer will lie in choosing a combination of complementary approaches.

Management of problems. There is no doubt that the alternatives to methyl bromide will require more sophisticated management of pest, disease and weed problems. You will need to better understand the problems, more accurately diagnose them, properly select appropriate control measures and integrate these into an effective and compatible program.

Try the alternatives. Study the alternatives, talk to experts and get their advice on your problems. Then while methyl bromide is still available, experiment on your farm by comparing the alternatives with methyl bromide. Remember to leave some untreated soil for comparison.

Artificial ripening

Artificial ripening of mature green tomatoes uses ethylene, a natural product of ripening fruit, to ripen fruit under controlled conditions.

Introduction

Artificial (controlled) ripening of mature green tomatoes involves exposing the fruit to ethylene gas. Ethylene gas is produced naturally by the fruit, but the extra ethylene speeds up ripening and makes it more uniform.

Fruit colour is determined by the temperature during ripening, as temperature has a direct influence on which pigment is produced within the fruit. In red tomatoes the main pigments are lycopene, which gives the red, and carotene, a yellow pigment. The ratio between lycopene and carotene in the fruit determines the colour. If there is more lycopene than carotene the fruit will be a deep red, while fruit with low lycopene and high carotene will be orange or pale red.

At temperatures up to 22°C lycopene (red) dominates. At 22°C and above carotene (yellow) appears and when a constant temperature of about 30°C is reached carotene will be dominant. Fruit ripens more quickly under warm conditions but a compromise has to be reached for controlled ripening to prevent yellow pigments appearing.

The most satisfactory fruit colour develops in the fastest time in the 18°C to 21°C range. Mature green fruit usually takes two or three days to reach quarter colour or stage 2 of ripeness at 20°C when exposed to ethylene gas.

A ripening room is a temperature controlled cool room adapted to contain ethylene gas to trigger the ripening process. Take care with ethylene gas as it may explode at high concentrations or if exposed to electrical sparks or naked flames. All electrical fittings in a gas room should be spark proof and safety vents must be fitted.

Store fruit in the gas room in bulk bins holding about 200 kg of fruit. Bins must be well slotted to allow good circulation of air through the fruit. Fruit should not be gassed in cartons because this will most likely result in fruit at different stages of maturity in each box. Mixed colour fruit in a box are commonly referred to as 'traffic lights'. Installing fan forced cooling units in the room will improve air movement and speed up cooling.

There are two main systems of introducing ethylene gas into a room — the single shot method and trickle ethylene injection, which is the main method used.

Single shot method

The single shot method is simple to operate and the gas metering equipment required is cheaper than for the trickle system. The electrical equipment is more costly because it has to be flame-proof to comply with safety regulations. Carbon dioxide produced by fruit respiration is not as easily controlled using this method and high levels will slow ripening.

The single shot method involves injecting a dose of ethylene into a gas-tight room to create an atmosphere of 250 milligrams per litre (mg/L, ppm), that is one volume of ethylene to 4000 volumes of air. The level of gas in the room falls as it leaks out of the room. To get good dispersal of gas it is usually introduced into the room behind the fan.

After every eight hours the room must be aired to purge the carbon dioxide. Open the doors with the fans running for about five to ten minutes. If the doors are opened at any time the room should be re-gassed. Leave the fans running all the times.

Inject another dose of ethylene after purging the carbon dioxide. This sequence is usually done over 24 to 48 hours.

Trickle ethylene injection

Trickle ethylene injection is the main method of ripening fruit. The trickle ethylene injection system involves injecting a continuous flow of ethylene into the room to maintain a concentration of 10 mg/L. Fresh air from outside is continually drawn into the room (at the rate of 1% of the room volume per minute) to expel stale air containing carbon dioxide. Check the flow rate regularly with an anemometer. The intake vent through the wall is placed on the upstream side of the fan. There is also a vent near the floor on the downstream side of the fan to allow stale air to be removed. Fruit can be put in or removed from the room at any time. Figure 14 shows the basic outline of ripening room.

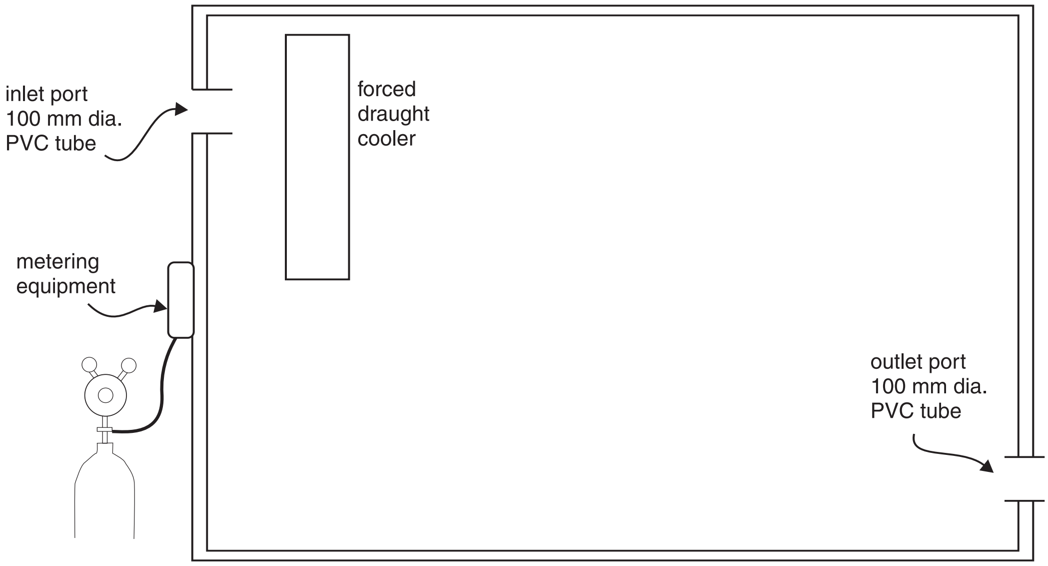


__Figure 14.__ A diagrammatic outline of a ripening room

more info
Installers of ripening rooms
Section 6 page 9

The ethylene metering system required is more complex than for the single shot method and includes a solenoid-operated valve to cut off the ethylene supply in case of a power failure. An air flow switch is also required in front of the fan to prevent ethylene being injected into the room if the fan is not working. Flame-proof wiring is not required if these safety requirements are met.

Figure 15 shows the basic ethylene injection equipment and set-up for a trickle ethylene ripening room.

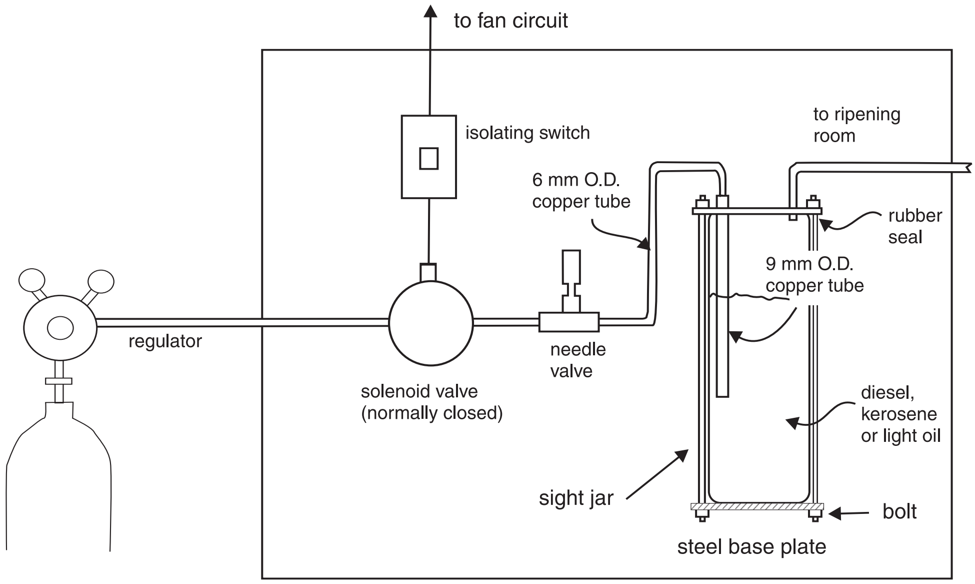


__Figure 15.__ Basic ethylene injection equipment and set-up for a trickle ethylene ripening room

Other production systems

Two alternative production systems that potential tomato growers may consider are organic and hydroponic production. The following notes provide a basic outline of key issues for potential producers.

HINT
A list of information sources and contacts for other production systems is in Section 6, Contacts and references.

Growing tomatoes organically

Organic production of tomatoes is very difficult because of the high number of pests and diseases that affect tomatoes and their susceptibility to these problems. Good isolation well away from major production areas would be essential.

Producing crops organically is usually understood to mean production without using synthetic chemicals. The philosophy of organic agriculture, however, is much more than that. Organic production systems are designed to produce high quality food while enhancing soil health, recycling organic wastes, increasing crop diversity and not relying heavily on external inputs. Organic production, therefore, seeks to protect the environment by working with rather than dominating the natural system.

Organic production is not a low input production system because the reduced use of chemicals and other external inputs generally needs to be offset by a higher level of management skills and labour inputs.

To maximise market advantage, organic producers should seek organic accreditation with one of Australia's three organic organisations:

- Biological Farmers of Australia
- National Association for Sustainable Agriculture
- Bio-Dynamic Agricultural Association of Australia.

The booklet *Organic agriculture — getting started* by David G. Madge is an excellent information source for prospective organic producers and well worth reading.

more info
Grower associations
Section 6 page 3

more info
Where to get this book
Section 6 page 18

Some points to consider in organic production

Production timing is critical to but does not ensure success. Warm weather production, particularly when frequent rainfalls can be expected, will increase the risk of diseases. Cool weather with heavy dews and fogs also will also increase the risk of some diseases. Pests are generally less likely to be a problem in cool conditions.

Crop rotation with other unrelated crops is important to managing disease and weed problems. Most organic growers have found that weeds are one of the more difficult problems to manage. Income derived from organic production needs to be spread over several different crops. This will reduce the adverse economic effects of a crop loss from pests, weeds or diseases that can be beyond the control of the organic farmer.

Monitor crops regularly for diseases and insect pests to help prevent problems. This is particularly important for managing heliothis (tomato grub, budworm) caterpillars and potato moth, major problems during warm weather.

There are few effective organic control measures for pests and diseases of tomatoes. Crop rotation and good farm and crop hygiene practices can help to reduce risks of disease outbreaks.

Organic fertilisers such as manures and compost are in effect slow release fertilisers, with nutrients being released over some months. The speed of availability is largely influenced by the weather. Tomatoes are a quick growing crop and shortfalls or excessive levels of nutrients, particularly nitrogen, will affect crop quality. It is more difficult to fine-tune nutrient supplies to the crop with organic fertilisers than conventional fertilisers.

Nitrogen applied from organic sources before planting is often released just as the plant should be setting its first fruit. Excessive nitrogen at this time sends the plant into a vegetative stage so plants are bigger than normal and early fruit set does not occur.

The often reduced quality and yields from organic production systems may not be offset by the higher prices that may be received. Do some extensive market research to determine the size of the organic market and the prices you can realistically receive for your produce, particularly for product that is not of the highest quality.

Growing tomatoes hydroponically

Newcomers to commercial vegetable production often see hydroponics as an attractive method for producing a crop. One of the reasons hydroponics may look attractive is that the varieties generally produced in this system fill niche markets that appear to fetch a good price at supermarkets and green grocers.

In Queensland hydroponic tomatoes are usually grown in bags with a dripper supplying water and nutrients. Management practices such as pruning and training are labour intensive and critical to the production of a high marketable yield. The plants are normally grown as a single stem trained up a string tied to an overhead wire and lowered as the plant grows and is harvested. The base of the plant will end up several meters from where fruit is being harvested.

The following notes are a summary from an excellent article by Greg Seymour *Beware the hydroponic shark* published in the magazine *Commercial Horticulture*. It makes interesting reading and we strongly recommend that you take the time to obtain a copy and read it with an open mind.

more info
Where to get this magazine
Section 6 page 24

Some points to consider in hydroponic production

Positives

Protected growing system. Hydroponic produce is usually grown in a protected system, that is a shade house or netted structure of some type that gives protection against the weather, for example rain, wind and hail. This type of system can be fine-tuned to produce superior quality produce that should give you a favourable marketing advantage.

Market competition. You will be a tomato producer producing hydroponically *not* a hydroponic producer growing tomatoes. Therefore, you will be competing on an existing market with both conventionally grown tomatoes and other hydroponic tomatoes; however the varieties grown hydroponically usually supply niche markets. Niche markets tend to be small and can be quickly oversupplied, resulting in a drop in prices.

Negatives

Newcomers to horticultural production are often in a poor position to realistically estimate the viability of hydroponic tomato production from biological, physical, managerial and financial perspectives. Here are some points to think about.

System failure. The physical system may fail to operate satisfactorily. Cautiously investigate any hydroponic schemes that appear to promise high returns. There is no such thing as a quick, easy buck in horticulture in the long term.

Labour intensive. The labour required for successfully managing hydroponic production and marketing is often seriously underestimated. Hydroponic tomato production is a labour intensive, time-consuming business.

Yields over estimated. Crop production can fail to reach estimated or predicted levels. A lot of things can go wrong in hydroponics and in some aspects, hydroponic production on a commercial scale is much more difficult than growing a crop in the ground.

a key issue
Gross margin
This section page 6

Profits over estimated. The gross margin profit and return to capital estimated either by yourself or the promoter of a particular hydroponic scheme may have been over estimated. When working out prospective costs and returns, err on the side of caution or better still talk to someone who is already producing hydroponic tomatoes commercially. Work through your costings and use a range of prices and yields to get a feel for how much money you could be risking.

Size of market. Market volumes and returns may be far less than expected. Do some intensive market research on how large your potential market is likely to be and what returns you could realistically expect. If you are unable to produce consistently high quality product, returns will be less, so include this in any calculations. In other words, consider your level of experience and your ability to learn fast.

Limited technical advice. Service and advice on hydroponic production from consultants, promoters, state government departments and tertiary institutions is limited. This is a major obstacle for new producers as sound, professional advice, particularly in the case of problems, may not be available when it is urgently needed. Seek to build up a network of contacts who can supply you with professional information and assistance.

more info
Hydroponics contacts
Section 6 page 24

Capital intensive. Financial institutions are generally reluctant to fund hydroponic ventures, perhaps partly because many of them have failed in the past. Hydroponics is a capital intensive business and you could be risking a great deal of your own and borrowed capital.

Experienced producers and some newcomers have managed to produce hydroponic tomatoes successfully, however, they have not become rich overnight. It is often difficult for people with no background in intensive horticultural production to assess if they have the managerial skills and work ethic needed to make hydroponics a success. In general, inexperienced people tend to overestimate their capabilities. Hydroponics is not easy and many things can go wrong.

Marketing and quality management

Marketing and quality management is a vital step in tomato production. How well you manage this, and the quality of your product, will have a big effect on whether you make a profit or loss from your tomato production.

How do you sell your tomatoes?

There are many options for marketing tomatoes. They include:

- selling to a local merchant
- selling to an agent or merchant at the major markets
- selling direct to a retailer (the major supermarkets or smaller retailers)
- selling overseas (either direct to buyers or through an exporter).

Note. Agents sell your produce on your behalf, then receive a commission, usually about 12.5%. Merchants buy the produce from you at an agreed price, then sell it for what ever price they can get.

Know your market

The fresh market tomato industry is characterised by static domestic demand and increasing supply. Surveys by the Queensland Fruit and Vegetable Growers Association have shown that increased sales of tomatoes can only be achieved by stimulating consumers to use tomatoes more often. To achieve this you must know your market and provide what they want. To know your market talk to people who are in constant contact with it, that is your agent/wholesaler and your retailer. To provide what they want you will need a quality management system in place.

Quality management for tomatoes

Tomato growers are implementing quality management systems driven by both customer demand and food safety legislation.

Customer demand

Consumers are becoming more demanding. They want tomatoes to be consistently acceptable in quality, be nutritious and safe to eat and they want convenience when buying. Their concerns about food safety have been heightened by recent outbreaks of food poisoning in other industries.

These consumer pressures have caused customers (retailers, processors, exporters, wholesalers) to be more demanding for quality and safety. Retail chains, for example, are increasingly requiring their suppliers to demonstrate that they have effective quality management systems in place. In other words, retailers want evidence that their suppliers can produce food that is safe to eat and will meet their quality requirements.

Most of the major retail chains in Australia are currently placing this requirement on selected direct grower suppliers and wholesalers. The wholesalers, in order to meet these requirements, in turn need to ensure that their grower suppliers have systems which will produce safe food of acceptable quality. After all, many of the food safety issues (particularly chemicals applied to produce) happen on-farm.

Processors and fast-food chains are also requiring their fruit and vegetable suppliers to have quality management systems in place to ensure supply of safe food.

What makes up a quality management system?

A quality management system consists of three main parts. These parts are common to all growing and packing businesses.

Product specifications

Product specifications describe the features of the product for sale so that there is no confusion for either customers or staff.

Product identification and traceability

Product identification and traceability is the method used to trace product from its point of origin in the field, through the packing shed to the customer. It also enables trace-back from the customer to the product's point of origin. A traceability code could be a 'packed on' date, but many packers prefer a code that only they can interpret. Letters of the alphabet can be printed on the carton and circled for different days, blocks, etc. This gives the grower the ability to trace back form individual cartons. Computer aided equipment that prints a code on each carton is also available.

Control of production processes

Control of production processes describes planning the production process and doing it correctly. This includes:

Monitoring of products, processes and services. These are checks to ensure that products meet specifications and that processes and services have been done correctly.

People (managers and staff). Motivated and well trained managers and staff are critical to the success of a business.

Customers and suppliers. This involves developing relationships with customers for mutual benefit, and working with suppliers to ensure raw materials (for example carton, chemical or seed suppliers) are satisfactory.

Documentation. This describes the documents that are used to support a quality management system. They may include manuals, records, checklists, procedures, work instructions, job descriptions, training guides.

Reviewing and improving the system. This means developing a process to regularly review operations and plan and implement improvements.

Improving quality management

Businesses can improve any of these parts to meet specific needs. For example:

- A business may want to improve traceability of product from the field to the packing shed. A product identification and traceability system can be developed to achieve this.
- Another business may want to improve product consistency. Clear documented product specifications, improved training of sorting staff and inspection of packed cartons with regular feedback to sorters can help achieve this.

What level of quality management is required?

The level of quality management required depends on what your customers require and what you need to run your business.

Customer requirements vary from an approved supplier quality system to a certified quality system standard incorporating HACCP (Hazard Analysis and Critical Control Points). HACCP is an internationally recognised method used to identify, evaluate and control hazards to meet customer requirements for food safety and quality. Quality and safety can not be separated and need to be integrated into the one quality management system.

Approved supplier quality system

An approved supplier quality system is required when growers who supply packhouses, marketing groups, wholesalers, exporters or processors must meet specific requirements to be an approved supplier to these customers. However, they may not need to have a certified quality system to meet these requirements.

Approved supplier requirements may include:

- following agreed procedures for critical operations
- keeping quality records such as a spray diary
- picking and packing to agreed quality standards
- implementing a food safety plan.

The customer (or on independent company on behalf of the customer) conducts audits to check that the grower meets the approved supplier requirements.

Certified quality system standards incorporating HACCP

A certified quality system incorporating Hazard Analysis and Critical Control Point (HACCP) is required where large growers or packhouses directly supply retail chains, processors, importers or where the next business (wholesaler, exporter) in the supply chain demands this requirement. The certified quality system standards incorporating HACCP which are relevant to the horticulture industry are:

- SQF 2000
- ISO 9002 plus HACCP
- customer quality management system standards.

For SQF 2000 and ISO 9002 an accredited independent company conducts audits to check that the grower/packhouse meets the quality system standard.

For customer quality management system standards, auditing is either done by the customer or an independent company on behalf of the customer.

Quality management system standards

A range of standards has been developed to enable businesses to have a recognised quality management system. The standards have been developed by international organisations, government departments or customers. To achieve accreditation, the quality management system is audited to check that it meets the requirements of the standard. Examples of standards for quality management systems include:

- international/national standards: ISO 9002, SQF 2000
- customer standards: Woolworths Vendor Quality Management Standard
- government quarantine standards: AQIS Certification Assurance (CA); Interstate Certification Assurance (ICA).

ISO 9002

ISO 9002 is an international standard for quality management systems. It consists of 20 elements covering all aspects of producing products and servicing customers. Most small growers will not have the resources nor the need to progress to ISO 9002.

SQF 2000

SQF 2000 was developed by Agriculture Western Australia for small businesses in the food industry. It is recognised in Australia, but not internationally at this stage. This standard consists of six elements incorporating aspects of ISO 9002.

It includes HACCP which is aimed at preventing food from being unsafe to eat. To achieve accreditation to SQF 2000, someone involved in developing the HACCP plan must have attended an approved HACCP training course.

Woolworths Vendor Quality Management Standard

Woolworths Australia have developed a quality management standard aimed at food safety and quality requirements for their own suppliers. It is an HACCP-based quality management standard.

AQIS Certification Assurance (CA)

Certification Assurance is a scheme established by the Australian Quarantine and Inspection Service (AQIS) as an alternative to end-point inspection. It is a voluntary arrangement between AQIS and an exporting business. The Certification Assurance system takes over the inspection function previously done by AQIS, which now monitors the effectiveness of the CA system by a regular program of audits.

Interstate Certification Assurance (ICA)

Interstate Certification Assurance has been developed by the state Departments of Agriculture as an alternative to inspection of product destined for states requiring treatment for fruit fly control. It consists of a series of operational procedures that must be followed by growers to meet interstate quarantine requirements. Queensland DPI audits each business at least once per year.

What is quality management going to cost?

There is no simple answer to this question.

Costs will depend on:

- size and complexity of the business
- what level of quality management is wanted
- how much knowledge the owner and staff have to develop and implement a system
- whether outside help is needed.

Types of costs include:

- owner's time (this is the biggest cost)
- the staff's time (developing and implementing quality management)
- for large businesses, staff positions dedicated to quality management (monitoring, documentation)
- materials (manuals, folders, posters, measuring equipment)
- training costs for owners and staff
- consultant fees (if outside help is needed)
- auditing costs (if aiming for accreditation).

Quality management is an investment

There is a pay off for quality management. As one grower has said: "An effective system does not cost, it pays". Like buying machinery, the time and money spent on quality management is an investment for future profitability.

Where to obtain more information

Queensland Horticulture Institute

more info
Contacts
Section 6 page 15

The DPI's Queensland Horticulture Institute (QHI) runs training courses in quality management. The course is aimed at helping growers to develop a quality system to meet their customers' requirements.

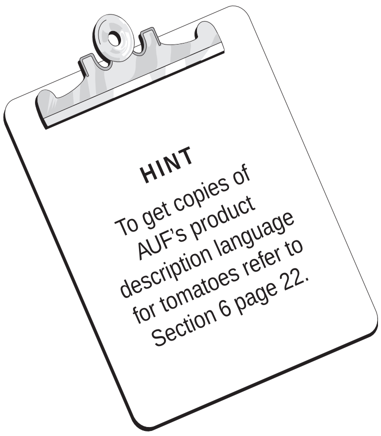
The Centre for Food Technology (CFT) run a three-day training course on HACCP specifically for the horticulture industry. CFT also provides consultancy services for businesses wanting to implement quality systems.

Other information sources

Copies of the SQF 2000 Quality Code and further information can be obtained from AGWEST at Agriculture Western Australia:

AGWEST Trade and Development
20th Floor, Forest Centre
221 St Georges Terrace
PERTH WA 6000
Ph: (08) 9322 7141; Fax: (08) 9322 7150

Grade standards



To meet both the agents' and consumers' expectations, tomatoes should be prepared so they will arrive at the final destination in a satisfactory condition. To facilitate a degree of understanding through the marketing chain, grade standards that describe quality, size and colour were developed for fresh market tomatoes in Queensland.

Australian United Fresh (AUF) have introduced comprehensive product description language for tomatoes. This language was designed to facilitate the objective description of tomatoes throughout the marketing chain. The product descriptions are being used by some parts of the industry in developing their quality management guidelines.

The grade standards that were traditionally used in Queensland are included below as a guide to the standards expected in the market place. These standards are no longer legally in force for domestic markets but are required for export.

Classification (quality grading classes)

Tomatoes were classed as Extra class, Class 1 or Class 2.

Note: A defect is any abnormal development of shape, colour or condition. A blemish is any surface disfigurement of the skin that will not affect keeping quality and includes slight chemical burns and healed injury such as insect damage, abrasions, scratches and rubs. Table 32 gives descriptions of the three classes of tomatoes.

Table 32. Descriptions of the three classes of tomatoes

Classification	Description	Comment
Extra class	Well formed and typical of the variety Firm Free from damage caused by pests and diseases Practically free from defects and blemishes other than very slight blemishes that do not affect the general presentation of the tomatoes in a package.	A package of Extra class tomatoes could contain a maximum of 5% by number or mass that did not satisfy the requirements of the class but satisfy the requirements of Class 1.
Class 1	Reasonably well formed and typical of the variety Reasonably firm Reasonably free from defects and blemishes They could have: slight defects in shape, development or colour slight healed growth cracks not more than 1 cm long slight blemishes and very slight bruises.	A package of Class 1 tomatoes could contain a maximum of 10% by number or mass not satisfying the requirements of the class but satisfying the requirements of Class 2.
Class 2	Satisfy the minimum requirements Be reasonably firm and not show unhealed cracks They could have: moderate defects in shape, development and colour provided that the tomatoes retain their basic quality and presentation moderate skin blemishes or bruises provided the fruit is not seriously affected and healed cracks are not longer than 3 cm.	A package of Class 2 tomatoes could contain a maximum of 10% by number or mass not satisfying the minimum requirements, except for fruit affected by rotting, marked bruising or any other deterioration making it unfit to eat.

Size grading

Size grades are no longer enforced on the domestic Australian market. The following grading systems are included as a guide to what the market has come to expect. The minimum size for tomatoes was 35 mm for round or ribbed varieties and 30 mm for elongated (egg) varieties. Traditionally tomatoes were size graded according to one of the systems in Table 32.

***Table 33**. Two systems for size grading tomatoes*

System 1		System 2
Cocktail	30 – 44 mm	30 – 34 mm for oblong tomatoes only
Small	45 – 59 mm	35 – 39 mm
Medium	60 – 79 mm	40 – 46 mm
Large	80 mm and over	47 – 56 mm
		57 – 66 mm
		67 – 81 mm
		82 – 101 mm
		102 mm and over

A package of tomatoes could contain a maximum of 10% by number or mass conforming to the size immediately above or below that stated on the package.

Tomatoes intended for export to OECD Scheme member countries must be sized according to System 2.

Colour grading

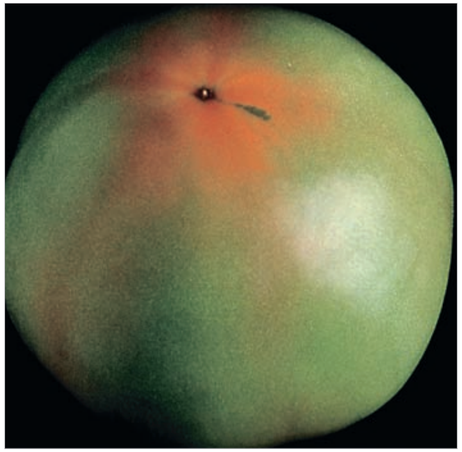
A tomato colour chart jointly prepared by the DPI and the QFVG is shown on the following page of this section to assist the industry to have consistent colour grading of fruit. Table 34 shows the categories listed.

Table 34. *Descriptions of the colour stages of tomatoes*

Stage	Colour	Description
Stage 1	Green	The surface is completely green; shade may vary from light to dark.
Stage 2	¼ colour	There is a definite break in colour to tannish yellow, pink or red on not more than 25% of the surface.
Stage 3	½ colour	More than 25% but less than 50% of the surface shows tannish yellow, pink or red colour.
Stage 4	¾ colour	More than 50% but less than 75% of the surface shows tannish yellow, pink or red colour.
Stage 5	Coloured	More than 75% of the surface shows pink or red colour.
Stage 6	Full colour	The entire surface has reached its maximum red colour.

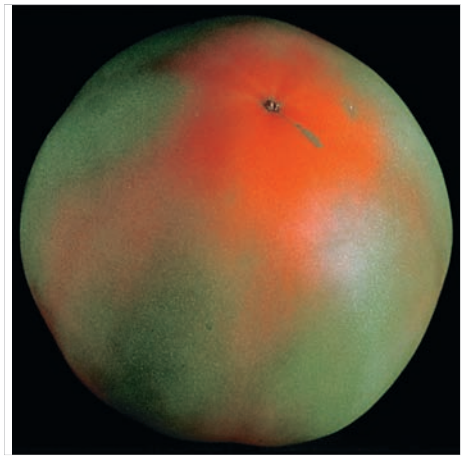
Stage 1
green

The surface is completely green — shade may vary from light to dark.



Stage 2
1/4 colour

There is a definite break in colour to tannish yellow, pink or red on no more than 25% of the surface.



Stage 3
1/2 colour

More than 25% but less than 50% of the surface shows tannish yellow, pink or red colour.

Stage 4
3/4 colour

More than 50% but less than75% of the surface shows tannish yellow, pink or red colour.

Stage 5
coloured

More than 75% of the surface shows pink to red colour.

Stage 6
full colour

The entire surface has reached its maximum colour.