Capsicum and chilli information kit

Reprint – information current in 1999

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 1999. We advise readers to take particular note of the areas most likely to be out-of-date and so requiring further research:

- Chemical recommendations—check with an agronomist or Infopest www.infopest.qld.gov.au
- Financial information—costs and returns listed in this publication are out of date. Please contact an adviser or industry body to assist with identifying more current figures.
- Varieties—new varieties are likely to be available and some older varieties may no longer be recommended. Check with an agronomist, call the Business Information Centre on 13 25 23, visit our website www.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 1999. The information is not current and the accuracy of the information cannot be guaranteed by the State of Queensland.

This information has been made available to assist users to identify issues involved in the production of capsicum and chilli. 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

This section contains more detailed information on some important decision-making areas and information needs. Use it in conjunction with Section 3. The information provided is not a complete coverage of the issue, but instead the key points that need to be known and understood.

Understanding the capsicum plant

An understanding of the plant will help you understand the conditions and treatments necessary to produce capsicums and chillies economically. They are rich sources of vitamins A and C and have increased in popularity in recent years as Australians eat more spicy foods. Botanically, the fruit are berries but are usually thought of as vegetables.

Plant types

Capsicums and chillies, or peppers as they are often referred to collectively, are perennial subshrubs native to South America. However, modern capsicums are generally grown as annuals, particularly in cooler climates. They are part of the nightshade family, *Solanaceae*, and are closely related to tomatoes, potatoes, tobacco and eggplant. The genus *Capsicum* includes all the peppers, from the mildest bell type to the hottest habanera. There are 23 species of capsicum currently identified but only five are major cultivated species.

The plants of the genus *Capsicum* vary greatly in habit and size. Although some tropical types grow as high as 5.5 m, the average height of cultivated plants is less than 90 cm. The leaves of the species vary from 6 mm long to about 130 mm. They arise singly and develop alternately along the stem. The pendant flowers have white, greenish-white, or purple petals. Flowers are pollinated by wind or by insects which can result in cross-pollination.

The colour of the fruit varies from green, yellow, white or purple in the immature stage to red, orange, brown, yellow, green or white in ripe fruit. Shapes can be round, conical, elongate, oblate or bell. Fruit range in size from 6 mm to more than 340 mm long and can be held erect or pendant on the plant.

The five major cultivated species are *C. annuum*, *C. frutescens*, *C. chinense* (these three are the most commercially important), *C. baccatum* and *C. pubescens*.

C. *annuum*, the most commonly cultivated species which includes the bell type capsicums, has white flowers, a toothed calyx and usually single-fruited nodes. C. *frutescens* has greenish flowers, a non-toothed, non-constricted calyx that encloses the fruit base, and mostly single-fruited nodes. C. *chinense* has white or greenish-white flowers, a constricted, toothed calyx, and usually one to three fruits per node.

C. *baccatum* has white flowers with yellow corolla throat spots, long curved pendant fruit pedicels and leaf petioles. C. *pubescens* has large, showy purple flowers, soft hairy leaves, yellow-orange fruits and black seeds.

Capsicums are considered to be self-pollinated but cross-pollination can and does occur. In some chilli types up to 42% cross-pollination due to bees has been recorded.

Effect of temperature

Capsicums and chillies thrive in warm conditions and produce best under a long growing season. The plants require a warmer climate than tomatoes and are more sensitive to temperature extremes. Light frosts can injure or kill them.

Optimum temperatures for seed germination range from 18° to 30°C, but gemination is very slow below 15°C and falls off rapidly above 35°C. Where day temperatures are high, germination can be enhanced if night temperatures are 10° to 15°C lower than day temperatures. Differences between cultivars in their ability to germinate at higher temperatures become obvious when temperatures reach 35°C.

For vegetative growth, optimum temperatures range from 20° to 30°C. Temperatures between 5° and 15°C result in poor growth and prolonged cloudy weather retards fruit bearing.

Fruit set is adversely affected at day temperatures above 32°C or night temperatures below 15°C. At day temperatures above 35°C few fruit set, and those that do may be malformed. Temperatures above 32°C or periods of hot drying winds and low humidity commonly cause abscission of buds, flowers and small fruit. Night temperatures lower than 10°C can also lead to flower abortion. Since flowers are only open for 24 to 30 hours, short periods of adverse conditions may influence the setting of individual flowers.

Cool conditions during fruit growth can lead to fruit buttoning, in which fruit length is reduced so that flatter than normal fruit result. This can be minimised by selecting cultivars less prone to this problem usually by selecting longer fruited types for production in cool conditions.

Overall, the temperature range over a 24 hour period is of less importance compared with the effect of the 24 hour mean temperature for fruit set, development and the fruit growth period of capsicum.

Temperature also controls the rate of development and the quality of the red pigment in fruit, irrespective of whether the fruit is on the plant or in storage. The optimum range for development of the red colour is 18° to 24°C. If fruit temperatures are consistently above 27°C, the red develops a yellowish tinge. As the temperature falls below 18°C, the colour development rate decreases and at about 13°C, colour development ceases. Sunlight and darkness have no effect on colouring except for the indirect effect on fruit temperature.

Capsicum species, particularly bell types, are also susceptible to sunburn. Exposed fruit may reach temperatures in excess of 38°C and burn, causing a sunken, tan, shrivelled area. Maintaining adequate foliage for protection of fruit is important. This can be achieved through adequate nutrition and control of foliar diseases.

The production period for capsicums and chillies is 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 for the major districts*

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

Crop cycle

Capsicums and chillies go through a vegetative growth stage before setting fruit. One suggested method of increasing yields and fruit size in less concentrated cultivars is to remove early flowers and fruit for several weeks. This tends to result in larger plants before the bulk of flowers and fruit are formed, resulting in a higher capacity for the plant to carry more fruit.

The fruit load of individual plants depends on stem size, amount of foliage and the extent of the root system. When the plant achieves its fruit load, it ceases flowering and stops producing fruit. Harvesting fruit in their largest, green mature stage can increase yields. The plant, not having to support this fruit, will continue flowering and setting fruits, producing higher yields.

While harvesting of green mature fruit will enhance overall yields, the market requirements often dictate that more red fruit is required. Modern cultivars, particularly of bell type capsicums, have been bred to develop concentrated maturity of fruit. These cultivars do not respond as well to continuous harvesting of green mature fruit, with later formed fruit becoming too small for market requirements. These cultivars are better managed as shorter-term crops harvested over a tighter period, with successive plantings made at short intervals.

Maintenance of adequate soil moisture is also important in capsicum and chilli production. Flowers can abort from irrigation stress and affect later yields; and blossom-end rot in fruit can also be induced by moisture stress. Stressing plants can also increase pungency (heat) in chillies. Restricting soil moisture will increase the amount of capsaicin (a group of alkaloids that give the sensation of heat) in the fruit. Pungency is also increased when the fruit ripens at higher temperatures rather than cooler ones. Nitrogen applied after fruit set can lower the capsaicin levels.

Fruit types

Bell capsicums usually have three or four lobes and are elongated or blocky. Chillies mostly have two lobes, but these are often not as distinct as in bell capsicums. Figures 1 and 2 show the different parts of capsicum and chilli fruit.

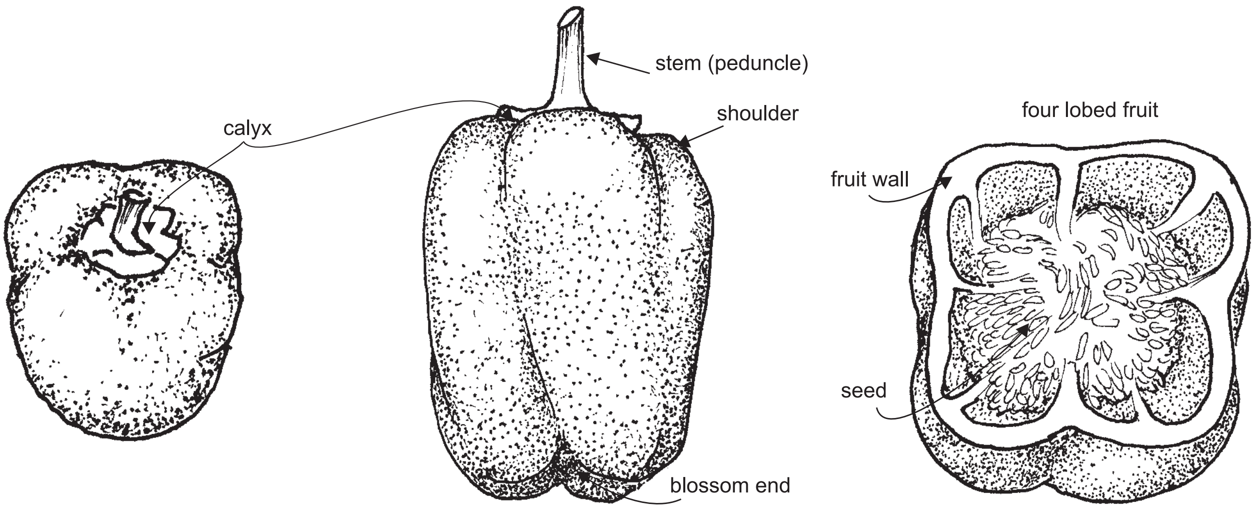
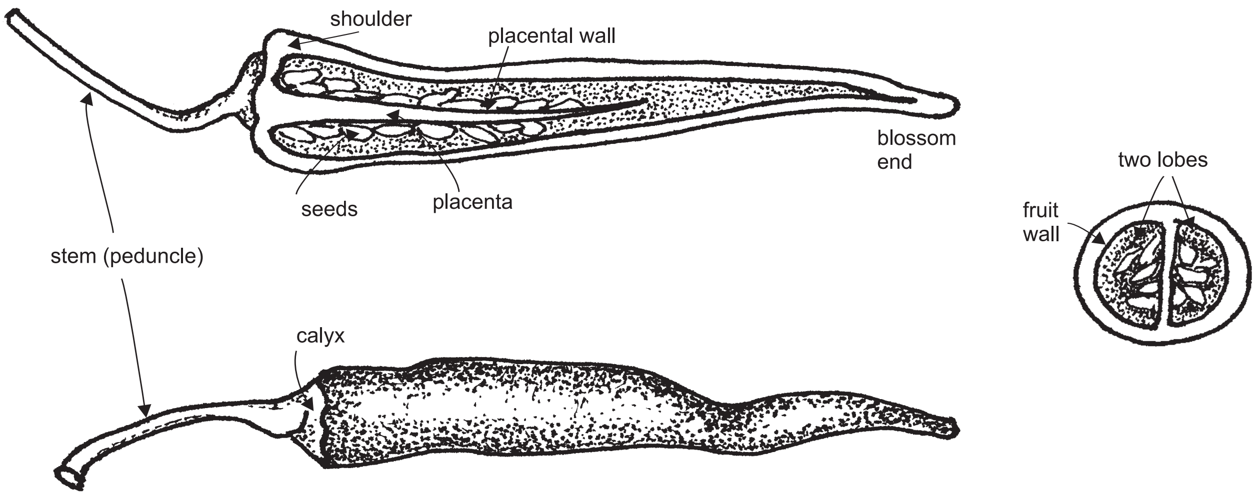


Figure 1. *The parts of a capsicum fruit*



Economics of production

One way of assessing the economics of capsicum production is by calculating the gross margin for the crop. 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 capsicums grown at Bundaberg and in the Dry Tropics and for chillies grown at Bundaberg.

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 and by the Queensland Farm Financial Counselling Service.

Glossary of terms

The following terms are used in the economic data presented. You will need to make your own calculations to determine these figures for your operation.

Gross margin. A gross margin is the difference between the gross income and the variable or operating costs. The calculation does not consider fixed or overhead costs.

Variable or operating costs. These costs include the growing, harvesting and marketing costs.

Fixed or overhead costs. These costs include rates, capital, interest, electricity, insurance and living costs. These fixed or overhead costs must be taken into account in calculating a whole farm budget.

Break-even price. The market price at which all growing, harvesting and marketing costs are recovered.

Break-even yield. The yield at which all growing, harvesting and marketing costs are recovered.

Cut loss price. The market price below which it is not worth harvesting. Above this price you will begin to recover your growing costs.

A capsicum gross margin for south-east Queensland (Bundaberg)

Enterprise unit: 1 ha of capsicums

REVENUE	Amount		$ /carton	Total $ /ha
Price ($/8 kg carton)			$10.00	
Cartons /ha	4 000			
TOTAL REVENUE				$40 000.00

VARIABLE EXPENSES	/ha	$/unit	$/ha	Total $/ha
Land preparation (F.O.R.M.)				
Ripping	1	$16.90 /ha	$16.90	
Disc harrowing	2	$15.70 /ha	$31.40	
Cultivation	2	$7.00 /ha	$14.00	
Rotary hoeing	1	$19.40 /ha	$19.40	
Bedding / forming	1	$34.00 /ha	$34.00	
TOTAL LAND PREPARATION EXPENSES				$115.70
Planting				
Seedlings (each)	33 000	$0.12	$3960.00	
Transplanter ($/ha)	1	$27.40 /ha	$27.40	
Casual labour	30 hours	$11.00 /hr	$333.00	
TOTAL PLANTING EXPENSES				$4 317.40
Fertiliser				
Ag-Lime (spread)	5 t	$50.00 /t	$250.00	
Crop King 55	350 kg	$0.56 /kg	$194.25	
MAP	30 kg	$0.52 /kg	$15.45	
Ammonium nitrate	70 kg	$0.44 /kg	$30.66	
Calcium nitrate	250 kg	$0.76 /kg	$190.00	
Potassium nitrate	260 kg	$0.96 /kg	$249.60	
Solubor	0.2 kg	$2.80 /kg	$0.56	
Sprayer	1	$3.00 /ha	$3.00	
Spreader	1	$5.00 /ha	$5.00	
TOTAL FERTILISER EXPENSES				$938.52
Fumigation				
Metham	500 L	$1.80	$900.00	
TOTAL FUMIGATION EXPENSES				$900.00
Weed control				
Spray.Seed 250	3 x 2 L	$10.20 /L	$61.20	
Sprayer ($/ha)	3	$3.00	$9.00	
Plastic mulch (black)	6 660 m	$0.09	$594.00	
Casual labour	8 hours	$11.00	$88.00	
TOTAL WEED CONTROL EXPENSES				$752.20

Gross margin continued ...

VARIABLE EXPENSES	/ha	$ /unit	$ /ha	Total $ /ha
Insect control				
(Applied with fungicides)				
Methomyl	10 x 2 L	$12.80 /L	$256.00	
Endosulfan	2 x 2.1 L	$9.60 /L	$40.32	
Pirimor	3 x 1 kg	$47.40 /kg	$142.20	
Nitofol	8 x 1.9 L	$37.50 /L	$570.00	
Dimethoate	6 x 0.75 L	$8.00 /L	$36.00	
Vertimec	2 x 0.4 L	$204.20 /L	$163.36	
TOTAL INSECT CONTROL EXPENSES				**$1 207.88**
Disease control				
Copper oxychloride	23 x 2.5 kg	$3.12	$179.40	
Wettable sulphur	3 x 3.5 kg	$2.38 /kg	$24.99	
Bravo 720	6 x 2 L	$21.90 /L	$262.80	
Sprayer ($/ha)	23	$3.00 /ha	$69.00	
TOTAL DISEASE CONTROL EXPENSES				**$536.19**
Irrigation				
Water charges	4 ML /ha	$37.20 /ML	$148.80	
Electricity: single pumped	4 ML /ha	$20.80 /ML	$83.20	
Pump repairs & maintenance	4 ML /ha	$16.00 /ML	$64.00	
Trickle tube	6 600 m/ha	$0.10 /m	$666.00	
Assume a 10 use life:				
Layflat 3 inch hose	200 m/ha	0.1 x $2.45/m	$49.00	
Layflat to trickle fitting	35 /ha	0.1 x $0.95 each	$3.33	
TOTAL IRRIGATION EXPENSES				**$1 008.33**
TOTAL GROWING EXPENSES			**$2.44 /carton**	**$9 776.22**

HARVESTING AND PACKAGING	Cost		$ /carton	$ /ha
Cartons				
Capsicum carton (8 kg)	4 000	$1.27	$1.27	$5 080.00
Harvesting & packing				
Labour: picking	30 ctn /hr	$11.00	$0.37	
Labour: packing	30 ctn /hr	$11.00	$0.37	
Harvest aid	30 ctn /hr	$8.00	$0.27	
Pre-cooling		$0.25 /ctn	$0.25	
Total harvesting expenses	4 000 ctns		$1.26	$5 040.00
TOTAL HARVESTING AND PACKING EXPENSES			**$2.53**	**$10 120.00**
MARKETING				
Freight (to Sydney)			$1.42	
Commission, levies	12.5%		$1.25	
Total marketing expenses	4 000 ctns		**$2.67**	**$10 680.00**
TOTAL VARIABLE EXPENSES			**$7.64**	**$30 576.22**

Gross margin = Total revenue minus total variable expenses

Total revenue	$40 000.00
Minus total variable expenses	– $30 576.22
GROSS MARGIN per HECTARE	**$9 423.78**

BREAK-EVEN YIELD at $10.00 per carton	2 037 cartons per hectare
BREAK-EVEN MARKET PRICE per carton (4 000 cartons /ha)	$7.31 per carton
CUT LOSS PRICE per carton (4 000 cartons /ha)	$4.51 per carton
GROSS MARGIN per MEGALITRE of IRRIGATION WATER	$2 356 per ML

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

On-farm price (market price less marketing costs)	$7.33
Harvesting and packing	$2.53

Therefore, it is worth harvesting

Actual gross margin when price or yield changes

		Price per carton				
Yield	cartons/ha	Low $8.00	$9.00	Medium $10.00	$11.00	High $12.00
Low	2 000	– $3 676	– $1 936	– $176	$1 564	$3 324
	3 000	– $626	$1 984	$4 624	$7 234	$9 874
Medium	4 000	$2 424	$5 904	$9 424	$12 904	$16 424
	5 000	$5 474	$9 824	$14 224	$18 574	$22 974
High	6 000	$8 524	$13 744	$19 024	$24 244	$29 524

Enterprise characteristics

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

Last update: March 1999

A capsicum gross margin for north Queensland (Bowen)

GROSS INCOME	Yield (8 kg cartons /ha)	Price per carton	$ /ha
	4 000	$10	40 000

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
Interrow herbicide	1	$11.12		$0.00	$11.12
Spray application	18	$7.78		$0.04	$124.48
Slashing	1	$4.09		$0.00	$4.09
Mulch removal	1	$16.37		$0.01	$16.37
Container-grown seedlings		36 000	$0.12	$1.11	$4 428.00
	Operations	**/ha**	**/unit**	**$ /carton**	**$ /ha**
Fertiliser					

Gross margin continued ...

Pre-plant					
CK55		350 kg	$0.52	$0.05	$182.00
Trickle					
MAP		30 kg	$1.40	$0.01	$42.00
Ammonium nitrate		70 kg	$0.48	$0.01	$33.60
Calcium nitrate		250 kg	$0.84	$0.05	$210.00
Potassium nitrate		260 kg	$0.81	$0.05	$210.60
Foliar					
Solubor		2 kg	$3.20	$0.00	$6.40
	Applications	**/ha**	**/unit**	**$ /carton**	**$ /ha**
Herbicide					
Spray.Seed	3	3.5 L	$9.98	$0.03	$104.79
Insecticide					
Nitofol	10	1.9 L	$38.17	$0.18	$725.23
Confidor	2	0.2 L	$389.20	$0.04	$155.68
Fungicide					
Copper	14	2.2 kg	$6.89	$0.05	$212.21
Sulphur	12	3.5 kg	$3.40	$0.04	$142.80
Water charges		5.5 ML /ha	$3.20 /ML	$0.00	$17.60
Labour cost		50 hours	$12.50 /hr	$0.16	$625.00
Irrigation					
Trickle tape		6 600 m	$0.12 /m	$0.20	$792.00
Layflat (4 inch, 4-year life)		50 m	$3.40 /m	$0.04	$170.00
Plastic mulch		6 600 m	$0.07 /m	$0.12	$462.00
Crop monitoring /ha			$156.00	$0.04	$156.00
TOTAL PREHARVEST COSTS				**$2.27**	**$9 067.13**
POSTHARVEST COSTS					
		cartons /hr	**$ /hr**	**$ /carton**	**$ /ha**
Harvesting and packing					
Picking		35	$12.50	$0.36	$1 428.57
Packing		25	$12.00	$0.48	$1 920.00
Pre-cooling				$0.39	$1 560.00
Cartons (27 L)				$2.30	$9 200.00
Machinery costs				$0.17	$680.00
TOTAL POSTHARVEST COSTS				**$3.70**	**$14 788.57**
MARKETING COSTS					
		$ /pallet	**pallets /ha**	**$ /carton**	**$ /ha**
Road freight (cooled)	Brisbane	$115.00	$41.67	$1.20	$4 791.67
(Pallet = 96 cartons)	Sydney	$190.00	0	$0.00	$0.00
	Melbourne	$220.00	0	$0.00	$0.00
Commission	12.5%			$1.25	$5 000.00
Levies ($1.10/package)				$0.11	$440.00
TOTAL MARKETING COSTS				**$2.56**	**$10 231.67**

SUMMARY TABLE		
	$ /carton	**$ /ha**
TOTAL PREHARVEST COSTS	$2.27	$9 067
TOTAL POSTHARVEST COSTS	$3.70	$14 789
TOTAL MARKETING COSTS	$2.56	$10 232
TOTAL VARIABLE COSTS	**$8.52**	**$34 087**

BREAK-EVEN PRICE	**$8.29**
BREAK-EVEN YIELD	**2 421**
CUT LOSS PRICE	**$5.67**

Gross margin = Gross income less total variable costs

	$ /carton	$ /ha
Gross income	$10.00	$40 000
Less		
Total variable costs	**$8.52**	**$34 087**
GROSS MARGIN	**$1.48**	**$5 913**

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

$ /carton	Gross	Variable	Gross
income	costs	margin	
$7	$28 000	$32 587	– $4 587
$8	$32 000	$33 087	– $1 087
$9	$36 000	$33 587	$2 413
$10	$40 000	$34 087	$5 913
$11	$44 000	$34 587	$9 413
$12	$48 000	$35 087	$12 913

Gross margin at different yields and prices

	Yield per hectare			
$ /carton	3 000	4 000	5 000	6 000
$7	– $5 707	– $4 587	– $3 467	– $2 347
$8	– $3 082	– $1 087	$908	$2 903
$9	– $457	$2 413	$5 283	$8 153
$10	$2 168	$5 913	$9 658	$13 403
$11	$4 793	$9 413	$14 033	$18 653
$12	$7 418	$12 913	$18 408	$23 903

Last update: March 1998

A chilli gross margin for south-east Queensland (Bundaberg)

Enterprise unit: 1 ha of hot red chillies

REVENUE	Amount		$ /carton	Total $ /ha
Price ($/3 kg carton)			$15.00	
Cartons /ha	6 000			
TOTAL REVENUE				**$90 000.00**

VARIABLE EXPENSES	/ha	$/unit	$/ha	Total $/ha
Land preparation (F.O.R.M.)				
Ripping	1	$16.90 /ha	$16.90	
Disc harrowing	2	$15.70 /ha	$31.40	
Cultivation	2	$7.00 /ha	$14.00	
Rotary hoeing	1	$19.40 /ha	$19.40	
Bedding /forming	1	$34.00 /ha	$34.00	
TOTAL LAND PREPARATION EXPENSES				**$115.70**
Planting				
Seedlings (each)	33 000	$0.12	$3960.00	
Transplanter ($/ha)	1	$27.40 /ha	$27.40	
Casual labour	30 hours	$11.00 /hr	$333.00	
TOTAL PLANTING EXPENSES				**$4 317.40**
Fertiliser				
Ag-Lime (spread)	5 t	$50.00 /t	$250.00	
Crop King 55	350 kg	$0.56 /kg	$194.25	
MAP	30 kg	$0.52 /kg	$15.45	
Ammonium nitrate	70 kg	$0.44 /kg	$30.66	
Calcium nitrate	250 kg	$0.76 /kg	$190.00	
Potassium nitrate	400 kg	$0.96 /kg	$384.00	
Solubor	0.2 kg	$2.80 /kg	$0.56	
Sprayer	1	$3.00 /ha	$3.00	
Spreader	1	$5.00 /ha	$5.00	
TOTAL FERTILISER EXPENSES				**$1 072.92**
Fumigation				
Metham	500 L	$1.80	$900.00	
TOTAL FUMIGATION EXPENSES				**$900.00**
Weed control				
Spray.Seed 250	3 x 2 L	$10.20 /L	$61.20	
Sprayer ($/ha)	3	$3.00	$9.00	
Plastic mulch (black)	6 660 m	$0.09	$594.00	
Casual labour	8 hours	$11.00	$88.00	
TOTAL WEED CONTROL EXPENSES				**$752.20**
Insect control (Applied with fungicides)				
Methomyl	10 x 2 L	$12.80 /L	$256.00	
Endosulfan	2 x 2.1 L	$9.60 /L	$40.32	
Pirimor	3 x 1 kg	$47.40 /kg	$142.20	
Nitofol	8 x 1.9 L	$37.50 /L	$570.00	
Dimethoate	6 x 0.75 L	$8.00 /L	$36.00	
Vertimec	2 x 0.4 L	$204.20 /L	$163.36	
TOTAL INSECT CONTROL EXPENSES				**$1 207.88**
Disease control				
Copper oxychloride	25 x 2.5 kg	$3.12	$195.00	
Wettable sulphur	3 x 3.5 kg	$2.38 /kg	$24.99	
Bravo 720	6 x 2 L	$21.90 /L	$262.80	
Sprayer ($/ha)	25	$3.00 /ha	$75.00	
TOTAL DISEASE CONTROL EXPENSES				**$557.79**

REVENUE	Amount		$ /carton	Total $ /ha
Irrigation				
Water charges	4 ML /ha	$37.20 /ML	$148.80	
Electricity: single pumped	4 ML /ha	$20.80 /ML	$83.20	
Pump repairs & maintenance	4 ML /ha	$16.00 /ML	$64.00	
Trickle tube	6 600 m/ha	$0.10 /m	$666.00	
Assume a 10 use life:				
Layflat 3 inch hose	200 m/ha	0.1 x $2.45/m	$49.00	
Layflat to trickle fitting	35 /ha	0.1 x $0.95 each	$3.33	
TOTAL IRRIGATION EXPENSES				**$1 008.33**
TOTAL GROWING EXPENSES			**$1.66 /carton**	**$9 932.22**

HARVESTING AND PACKAGING	Cost	$ /carton	$ /ha	
Cartons				
Chilli cartons (3 kg)	6 000	$1.21	$1.21	$7 260.00
Harvesting and packing				
Labour: picking	2 ctn/hr	$11.00	$5.50	
Labour: packing	4 ctn/hr	$11.00	$2.75	
Pre-cooling		$0.25 /ctn	$0.25	
Total harvesting expenses	6 000 ctns		$8.50	$51 000.00
TOTAL HARVESTING AND PACKING EXPENSES			**$9.71**	**$58 260.00**
MARKETING				
Freight (to Sydney)			$1.10	
Commission, levies	12.5%		$1.88	
Total marketing expenses	6 000 ctns		**$2.98**	**$17 880.00**
TOTAL VARIABLE EXPENSES			**$14.35**	**$86 072.22**

Gross margin = Total revenue minus total variable expenses

Total revenue	$90 000.00
Minus total variable expenses	– $86 072.22
GROSS MARGIN per HECTARE	**$3 927.78**

BREAK-EVEN YIELD at $10.00 per carton	4 300 cartons per hectare
BREAK-EVEN MARKET PRICE per carton (6 000 cartons /ha)	$14.25 per carton
CUT LOSS PRICE per carton (6 000 cartons /ha)	$12.35
GROSS MARGIN per MEGALITRE of IRRIGATION WATER	$982 per ML

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

On-farm price (market price less marketing costs)	$12.02
Harvesting and packing	$9.71

Therefore, it is worth harvesting

Actual gross margin when price or yield changes

		Price per carton				
Yield	cartons/ha	Low		Medium		High
		$11.00	$13.00	$15.00	$17.00	$19.00
Low	4 000	– $14 676	– $7 678	– $692	$6 346	$13 338
	5 000	– $15 862	– $7 115	$1 618	$10 415	$19 155
Medium	6 000	– $17 048	– $6 551	$3 928	$14 485	$24 973
	7 000	– $18 234	– $5 988	$6 238	$18 554	$30 790
High	8 000	– $19 420	– $5 424	$8 548	$22 624	$36 608

Enterprise characteristics

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

Last update: March 1999

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

Advantages of container-grown seedlings

- Seedlings are raised in a sheltered environment when outside conditions are unsuitable and 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.
- No losses in the field from cutworm or wireworm attack.

Disadvantages of container-grown seedlings

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

Growing container-grown seedlings

Seedlings are best grown by nurseries who have the right equipment and expertise to grow plants well. Poorly grown plants have a lower yield potential than well-grown, sturdy plants. Some growers, however, 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 2.

Mix ingredients thoroughly, add about 5 L of water and mix again. This dampens the peat so that water penetrates more easily into the filled trays. 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 2. *A mix used for growing container-grown 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 will result. The 64 cell Speedling tray and 90 cell plastic trays are commonly used for capsicum and chillies. If cells are too small, seedlings will be soft, lanky and more susceptible to disease.

Planting

Fill trays evenly with mix. Plant two or three seeds per cell for open pollinated varieties and cover with 6 mm of mix or vermiculite. Thin to one plant per cell when two weeks old. For expensive hybrid seed, planting only one seed per cell can be justified though 5 to 10% of cells will not germinate. Some nurseries plant extra seeds in some cells then 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. Using this method about 250 seedlings per gram of seed are produced.

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 to work with.

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 (μS/cm) is essential for good vigorous seedling growth. Above this level, reduced growth and leaf burn become a problem.

Watering should be slow to ensure complete wetting of the mix. Over watering is a mistake easily made 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 water distribution from the small sprinklers used in nurseries. Trees or shade cloth windbreaks 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.

These 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 every one to two days to control bacterial diseases. If necessary, spray to control insect pests such as aphids, heliothis and leafminer 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 (Figure 3). For cup transplanters, seedlings should be more than 12 cm tall for best results. Waterwheel planters are not affected by seedling height; however, 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.

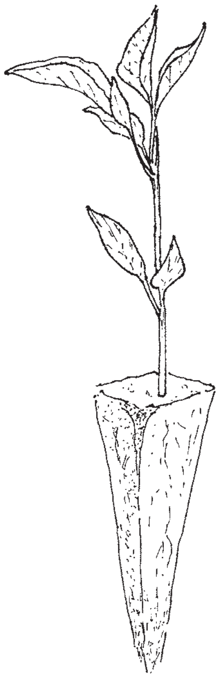


Figure 3. A seedling ready for planting

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.)
- regularly check the conductivity of the water;
- 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 roots dry out if they come out of the mix.)
- 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.)

Capsicum and chilli varieties

The quality of capsicum 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

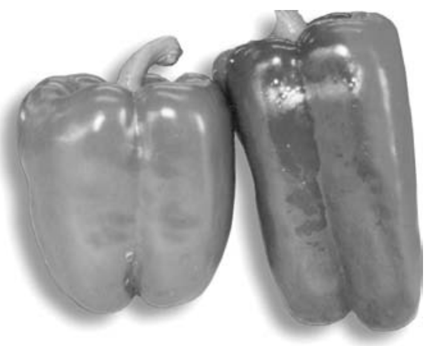
Variety selection is an important decision as there is no one variety that performs best across all planting seasons and production techniques. Fruit size is usually smaller in cool weather. Varieties that are too large for summer production may be ideal for fruit set in winter.

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 capsicums and chillies

Capsicums

Bell. These are the main capsicum-type grown and have three or four lobes. Varieties that are green when immature and turn red on maturity are most common. There is also a small market for varieties that turn yellow, orange, purple or black. Bell capsicums have sweet, thick flesh.

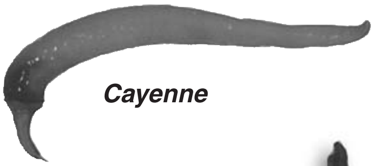


Left: blocky bell type. Right: elongated bell type

Long sweet yellow (banana). These are long (up to 20 cm), tapered fruit which change colour from green to yellow to red. They are usually harvested when yellow.

Elongated long, sweet yellow type

Birdseye



Cayenne

Habanero

Horn

Jalapeno

Serrano

Large processing

Chillies

Chillies are basically capsicums that taste hot due to the presence of capsaicin, a group of alkaloids that give a sensation of heat. Most of the capsaicin is in small glands around the placental tissue that holds the seed. As small-fruited types have a higher percentage of placental tissue to flesh than large types, they are usually hotter.

The heat level or pungency is usually measured as Scoville units in a given weight of chilli tissue and varies from 100 to 500 units for the mild bell types up to over 300 000 units for habaneros. The Scoville test is based on people tasting a diluted sample of the chilli. Newer testing methods using high performance liquid chromatography are more accurate and consistent. The pungency of chillies will vary, depending on variety and environmental conditions. Stress will increase heat levels.

The following descriptions of some of the main types of chillies are from a DPI Note, *About chilli peppers*, by A.M. Hibberd.

Bell chillies. These are similar to bell capsicums only mildly hot.

Birdseye. Fruit are 40 to 50 mm long, thin and pointed with two lobes and flesh about 1.5 mm thick. They are very hot, about 30 000 to 50 000 Scoville units and usually sold on the fresh market.

Cayenne. Fruit are long and thin with 2 mm thick flesh. They are a medium heat fruit, 5000 to 25 000 Scoville units and usually sold on the fresh market.

Habanero. These are a different species to other chillies and are exceptionally hot, up to more than 300 000 Scoville units. Fruit are thin-fleshed and shaped like a Christmas decoration. They have a niche fresh market and are used for processing.

Horn. Fruit are long like cayenne but broader, about 25 mm, and slightly curved. Flesh is 2 to 3 mm thick and mild to medium heat varying from 1000 to 10 000 Scoville units. They are a fresh market type popular in Taiwan and Korea.

Jalapeno. These are very popular in Mexico and the USA, and are pronounced 'hal-uh-pen-yah'. Fruit are 9 cm long and 30 to 40 mm wide. Flesh is 4 to 5 mm thick, so fruit are heavy, about 30 g. They have excellent flavour and are ideal for fresh market or processing. They develop surface netting similar to rockmelons as they mature. Heat levels vary from mild to medium, 1000 to 15 000 Scoville units, depending on variety.

Serrano. Fruit are cylindrical, 2 to 6 cm x 1 to 2 cm with thick flesh and a tapered, rounded end. The bright, dark green fruit which turn red are hot 5000 to 15 000 Scoville units and suitable for salsa, pickles and roasting.

Large processing type. The two lobed fruit are 15 to 20 cm long, with 3 to 5 mm thick flesh and weigh 35 to 70 grams. Heat levels vary from mild to medium, 1000 to 15 000 Scoville units, depending

Large fresh market

on variety.

Large fresh market type. These are similar to the processing type above, but about two-thirds the size.

Dried fruit type. Any chilli except the very thick fleshed types can be dried and sold whole, in pieces or powdered for niche markets. When crushed into small pieces, or sprinkles, small thin-fleshed types give a balance of yellow from the seeds and red from the flesh and are used to sprinkle over food.

Variety descriptions

The variety descriptions below have been supplied by the seed companies listed. Table 3 shows the codes used to identify the seed companies.

more info

Seed companies
Section 6 page 4,5

Table 3. *Seed company identification*

Code	Company	Code	Company
C	Charlcon Seeds	N	Novartis Seeds (S&G)
F	Fairbanks Seeds	RZ	Rijk Zwaan
H	Henderson	SPS	South Pacific Seeds
LV	Lefroy Valley	Y	Yates

Table 4 shows the codes used to identify disease resistance or tolerance.

Table 4. *Disease resistance or tolerance identification*

Code	Disease	Code	Disease
Bls	Bacterial leaf spot	TEV	Tobacco etch virus
PMMV	Pepper mild mottle virus	TMV	Tobacco mosaic virus
PVY	Potato virus Y	Ys	Yolo spot (Stip)

Note: Bls race 2 is not known to occur in Queensland, races 4 and 5 do occur. Tobacco etch virus is not known to occur in Australia.

Sweet bell capsicums

Aries (SPS). This hybrid produces medium long, four-lobed fruit with thick walls. The glossy 13 cm x 9 to 10 cm fruit are a uniform dark green which turn red at full maturity. Plant habit is semi-compact. Aries features an extremely high yielding ability, especially in the latter picks. Tolerance or resistance: TMV.

AU 98 E (RZ). Large lamuyo (elongated) type for crops outside or under cover. Fruit size slightly bigger than Zafiro. Long, vigorous plants supporting a high fruit load. Productive, good quality and fast to turn red. Tolerance or resistance: TMV2.

Aztec (CP 563) (N). Mid early, 78 to 80 days from transplant. Reasonably compact for a Bls hybrid but prefers lower fertiliser applications than non-Bls lines. Very productive, large-leaved plant. Medium green to yellow, large, blocky fruit 11 cm x 10 cm with thick walls 6 mm plus. They remain firm at yellow compared to others of this type. Suited to open field production in mild to warm growing circumstances. Tolerance or resistance: Bls1,2,3.

Baron (C). A very early hybrid, 70 days from transplanting, has a strong, very productive plant producing very large, thick-walled, blocky, 13 cm x 13 cm, four-lobed fruit. High quality fruit very suitable for export because of its very firm wall. Excellent glossy green to very attractive bright red fruit that is recommended for harvest. Tolerance or resistance: TMV0, PVY.

Belair (SPS 862). Large, blocky hybrid that offers better uniformity of shape and improved size over Merlin. Slightly shorter bush than Merlin, excellent leaf cover for sunburn protection, and consistently high yields, with a better early set. Extra thick walls, 7 to 9 mm, and consistent four-lobed, blocky shape. Under higher temperatures, the plant will remain compact and has the ability to retain its lower set under these conditions. Tolerance or resistance: Bls1,2,3, TEV, TMV, PVY.

Belltower (CP 062) (N). Blocky hybrid, 72 to 76 days from transplant under warm weather conditions. Medium height, has good vigour which maintains growth even under cool growing conditions. The foliage is well distributed and the prolonged setting ability allows high numbers of fruit to be maintained. Long, blocky fruit 13 cm x 10 cm. Medium to dark green turning deep rich red at maturity. Walls are thick at 5 to 6 mm and the even size and shape has meant this is a preferred choice by growers for quality and yield. Suited for indoor and outdoor culture. Tolerance or resistance: TMV, PVY.

Belmore (H). Blocky to long blocky, medium sized hybrid which produces dark green predominantly four-lobed, uniform fruit which are about 14 to 15 cm x 10 cm. Tolerance or resistance: Bls, TMV, PVY.

Blackbird (C). This hybrid takes 73 days from transplanting. A unique 12 cm x 15 cm, purple x brown cross which ripens green/brown/black/dark red.

Blitz (Y). Maturity from transplant is 10 to 12 weeks. Blocky to half-long, four-lobed hybrid 10 to 12 cm x 9 to 10 cm. Attractive, green fruit turning red of very even size and shape. Bush is more protective than competitor lines and maturity is slightly quicker. Excellent yield potential and concentrated picking, with the fruit shape preferred by wholesalers to maximise profits. Tolerance or resistance: Bls1,2,3.

Blockade (CP 474) (N). Elongated, blocky hybrid. Mid to late season, 80 to 87 days from transplant. Medium vigour plant with good leaf cover and continuous setting of flowers. Plants actively continue to grow and set fruit in a similar manner as Belltower. Elongated, three to four-lobed fruit, 13 cm x 9 cm with the ability to produce slightly larger fruit in the first set. Consistent large size in a Bls line. Blockade is green to red and very attractive at either colour stage. Suited to the fresh market and open field culture. Highly adaptable through different growing circumstances. Tolerance or resistance: TMV, PVY, Bls1,2,3, Ys.

Blockbuster (C). This improved hybrid takes 75 days from transplanting, has the adaptability and high yields that made Blockbuster popular, plus outstanding disease resistance. The glossy, dark green fruit has three to four lobes, with extra thick walls and plenty of weight. Fruit averages 16 cm long and 13 cm wide. The plants produce well in all areas, bearing main season peppers that mature to red. Tolerance or resistance: TMV, Bls1,2,3.

Blue Jay (C). This hybrid takes 73 days from transplanting. Very productive and novel, ripens green/lilac/grape/pale orange/dark red. Fruit is blocky, 11 cm x 10 cm.

Bombadier (F). Medium to large, three-quarter long, three to four-lobed, glossy green to fire engine red. Medium sized bush producing big yields of quality fruit. Compare to Aries, Target and Raptor. Tolerance or resistance: Bls1,2,3, TMV, PVY.

Bullseye (F). Solid, blocky, four lobe type. Smaller bush but loaded with fruit. Brilliant deep red from green. Compare with Merlin. Tolerance or resistance: Bls1,2,3 PVY, TMV.

Bullseye (H). Very high yielding lamuyo style hybrid which produces 12 to 17 cm x 8 to 10 cm fruit on a medium sized bush with good cover. Fairly early maturing, uniform and definitely worth trying against other lamuyo varieties. Suitable for indoor or outdoor production. Tolerance or resistance: TMV, PVY.

Canary (C). This hybrid takes 72 days from transplanting. Blocky, 14 cm x 13 cm, four-lobed fruit. Plants are very productive. Fruit have very thick walls and mature a bright yellow. Ripens medium green/yellow. Tolerance or resistance: TMV.

Cardinal (C). This hybrid takes 70 days from transplanting. Blocky, 11 cm x 11 cm four-lobed fruit, plants are open and easily picked. Best thick-walled, dark green variety that ripens dark red for uniformity and cold tolerance. Tolerance or resistance: TMV.

Cardinal (Y). Maturity from transplant is 10 to 12 weeks. Blocky green turning red, hybrid bell, four-lobed, 9 to 10 cm x 10 to 11 cm. Very glossy and holds its colour well.

Chocolate Bell (C). This hybrid takes 86 days from transplanting. A medium early to predominantly four-lobed blocky fruit. The good sized, 12 cm x 12 cm fruit mature from medium green to a rich chocolate.

Chocolate Star (C). This specialty hybrid takes 75 days from transplanting. Fruit is medium early to early, predominantly four-lobed, blocky, sweet capsicum. The fruit mature to green to a rich chocolate. The plants are very strong, well open and produce very attractive good size fruit. Very productive. Tolerance or resistance: TMV2.

Commandant ™ (CP 358) (N). Mid-season hybrid 80 days from transplant. Strong foliage and field standability of plants. Medium tall in height with slightly open habit, which facilitates good fruit shape and size. Fruit are borne on the outside of the plant, reducing pinching and deformed fruit. Green to red fruit with long, blocky, base shape. Fruit are thick-walled, 5 to 7 mm, and do not pinch in shape to the same degree as other varieties. The concentrated set and blocky shape gives a very high, first class, quality packout. Fresh market and processing type suited to both indoor and outdoor production with concentrated setting, which enables high, early yields. Strongly adapted for warm to hot growing periods. Heat tolerant. Easy to pick. Tolerance or resistance: PVY, TEV, Ys.

CP 385 (N). Short, blocky hybrid with best results picking in warm/hot conditions. Tolerance or resistance: TMV, PVY, Bls1,2, Ys, TEV.

CP 647 (N). Improved Blockade type hybrid with extra fruit firmness at red stage provided the plant isn't over fertilised early and is watered properly at harvest. Tolerance or resistance: TMV, PVY, Bls1,2,3, Ys, TEV, PMMV.

Cuby (CP 427) (N). Blocky mid to mid-late-season hybrid 78 to 86 days from transplant. Plants have good foliage and a short to medium internode distance. Very productive with extended growth for long crop culture. Suited to wire or stake culture. Blocky fruit, 10 cm x 10 cm with three to four lobes and good firmness, green to red with relatively quick colour change. Plants are sturdy and tolerate prolonged harvesting. Thick-walled, the yield over extended growing periods is very high. For best appearance, fruit should be cut from the plant rather than breaking. Suited for both fresh market and export. Strong plant in both indoor and outdoor crops. Tolerance or resistance: TMV3.

Domino (Y). Maturity from transplant is 11 to 13 weeks. Long, hybrid bell, green turning red, three to four-lobed, 15 to 16 cm x 8 to 9 cm. Rugged, adaptable, continuous cropper. High yields of elongated bell-shaped fruit, which retain size and wall thickness over a long period. Good field tolerance to many diseases.

Dove (C). This hybrid takes 71 days from transplanting. Large, productive 15 cm x 12 cm should be harvested immature for creamy, near white appearance. Good leaf cover. Ripens pale green/cream pale yellow/pale orange/red.

Early Red (C). Fantastic yields and taste, the best flavour of our hybrid capsicum, colours from green to outstanding mature red earlier than other capsicums. Produces twice as much as other capsicums. Medium size, 11 cm x 10 cm, thick walls.

Eclipse (LV). A large, half-long, blocky, four-lobed green to red hybrid. Fruit stay straight and do not show a tendency to twist. Fruit are prolific and set well, even under adverse conditions. Fruit stay firm once red and colour quickly and evenly. Performing well in Bundaberg. Tolerance or resistance: TMV, PVY.

Elite (C). A very early, elongated, hybrid capsicum. Strong plants produce long, bell type, smooth, shiny, thick-walled fruit with an average weight of 200 g. At maturity the four-lobed fruit turn bright red with good flavour. Tolerance or resistance: TMV, PVY, TEV, Ys.

Flamingo (SPS 7-143) This hybrid produces attractive medium sized, four-lobed, blocky fruit with exceptional firmness and offers one of the best keeping qualities available, both on the plant and in the market place. The three colour stages—ivory wax, turning to pink-orange and then red at full maturity—offer growers greater flexibility and options at harvest for the specialist coloured market. Tolerance or resistance: Bls1,2,3, PVY, TMV.

General (C). This hybrid takes 74 days from transplanting. Large, slightly elongated, uniform, thick-walled, dark green fruit make General a classy productive sweet capsicum. Plant habit is strong growing with good leaf cover for fruit protection. General is suitable for fresh as well as processing markets. Smooth fruit, excellent shape, dark green to nice beautiful red. Good size, 15 cm x 13 cm. Tolerance or resistance: TM2.

Gold Finch (C). This hybrid takes 72 days from transplanting. Pale lemon yellow, large, 15 cm x 12 cm, blocky, four-lobed bell, ripens light green/creamy yellow/pale lemon/red.

Golden Buster (C). This hybrid bell type produces uniform large to extra large, deep, blocky, glossy green to yellow fruit, with a smooth shoulder and concentrated fruit set. The plant averages 50 to 60 cm tall and has wide adaptability. Tolerance or resistance: Bls1,2,3, TMV.

Golden Emperor (Y). Maturity from transplant is 11 to 13 weeks. Blocky green turning golden yellow hybrid bell, four-lobed, 10 cm x 10 cm. Tolerance or resistance: Bls1,2,3.

Golden Star (C). This very early variety takes 70 days from transplanting. It sets fruit easily under the stress of hot or cold temperatures. The yellow fruit are thick-walled and uniformly sized with excellent quality, good size, 15 cm x 15 cm. Golden Star is suitable for winter production in mild regions, ripens to a dark glossy green turning to bright yellow. Tolerance or resistance: TMV0, PVY0,1.

Heldor (LV). Previously marketed as Golden Gem. Hybrid plants are strong and vigorous with medium early maturity. Fruit are four-lobed, large, half-long and blocky, 15 cm x 8 cm, turning from green to intense yellow. Fruit colour evenly and quickly and are very firm. Tolerance or resistance: TMV.

Hot Spot (SPS). Hybrid capsicum with hotset ability. Earlier to turn red and has a slightly shorter plant than Merlin with excellent cover. Concentrated harvest of heavy, thick-walled, smooth fruit with high quality and consistent blocky shape, even under high temperature conditions. Dark green turning to a fire engine red. Hot Spot is restricted to early season production, January to March sowing in north Queensland. Tolerance or resistance: Bls1,2,3, TEV.

Inca (N). Medium/large, blocky, yellow hybrid with excellent shape, colour and firmness. Very quick to change colour. Very good field capacity. Best suited to cool production times. Tolerance or resistance: TMV.

Ivory Star (C). This variety takes 70 days from transplanting. This unique, ivory coloured, bell capsicum is ideal for the specialty gourmet market. Vigorous erect plants produce high yields of good size, 12 cm, blocky, three to four-lobed fruit. Very tolerant of sunburn. Ivory to yellow at full maturity. Tolerance or resistance: PVY, TMV, Ys.

Jive (RZ). Short, blocky type for indoor and outdoor production. Very thick walls and well-shaped glossy fruit, average weight 180 g. Productive, good quality. Tolerance or resistance: TMV2.

Lavender Star (C). This variety takes 70 days from transplanting. These strikingly coloured, specialty market fruit change from ivory to lavender to red. Lavender Star holds its uniform light lavender shade longer, offering more flexibility in harvesting and marketable yields. Moderately vigorous plants provide good cover for the three to four-lobed, blocky fruit that grows 12 cm x 11 cm. Tolerance or resistance: TMV.

Legend (C). This hybrid takes 78 days from transplanting. Legend has regular continuous growth. The high productivity of quality, thick-walled, uniform, 13 cm x 12 cm fruit meet the market requirements. Nice colour ability both in green and red, it is recommended for fresh market and processing. Legend produces large fruit even when less than favourable environmental conditions prevail. Tolerance or resistance: TMV0, PVY.

Legend (LV). High yielding, blocky hybrid working well in north Queensland for early sowing. Plants are compact and have exceptional cover and strong vigour. Fruit are four-lobed and very blocky, 12 cm x 10 cm, and very firm at both the green and red stage. Tolerance or resistance: TMV, Bls1,2,3.

Lemon Beauty (CP 184) (N). Early hybrid 68 to 75 days from transplant. Medium vigorous with light green leaves and purple colouration at the nodal points. Leaves are medium large, and protect the fruit and the tall plant sets fruit well through the plant. Medium blocky fruit, 11 cm x 8 cm, usually four-lobed and coloured light green/ivory and turning gold/deep yellow on maturity. Slow colour change, harvested mainly at ivory stage. Suited to outdoor and indoor crops. Tolerance or resistance: TMV, PVY, Ys.

Major (C). This green to red hybrid capsicum has thick walls and the high quality fruit are smooth. Strong, vigorous fruit measures about 17 cm x 13 cm with an average weight of 220 g. Tolerance or resistance: TMV, PVY, TEV, Ys.

Mamba (Y). Maturity from transplant is 10 to 12 weeks. Blocky green turning red hybrid, half-long, four-lobed, 13 to 14 cm x 9 to 10 cm. Longer fruit than Blitz with similar yield and quality. Adapted to many growing regions. Alternative to full blocky types. Warm weather causes fruit to be very short. Tolerance or resistance: Bls1,2,3, PVY.

Market Buster (C). This hybrid variety takes 70 to 76 days from transplanting. If you'd like to fill the gap in your capsicum program take another look at Market Buster. This capsicum commands top honours for its high-class combination of high potential yields. It produces a strong, erect bush and high yields of extra large, 13 cm x 13 cm blocky fruit. Continuous large fruit even when the weather turns cool because its blocky to slightly blocky shaped fruit is resistant to flattening. Tolerance or resistance: Bls1,2,3.

Merlin (SPS). One of the best commercial, bacterial spot resistant hybrid lines available. The strong plant offers good leaf cover and sunburn protection, with good tolerance to spot during the wetter parts of the season. Produces very uniform, smooth, blocky, four-lobed, glossy dark green, 9 to 10 cm x 12 to 13 cm fruit. Thick walls ensure good firmness is maintained well after harvest. Offers excellent weight to size ratio. Well suited to autumn and spring in northern areas for early and late harvest. Tolerance or resistance: Bls1,2,3, PVY, TMV, TEV.

Midas (CP 98) (N). Mid-season hybrid 75 to 82 days from transplant. Vigorous plants with good leaf cover and high yield. Sets well under cool growing conditions and is a prolonged setting type. Blocky, 10 cm x 9 cm, green fruit changing to yellow at maturity. Midas is suitable for the fresh market at both green and yellow harvest. Very sweet and attractive colour, Midas is suitable for both indoor and outdoor culture and may be pruned to one or two leaders. Heavy fruit/box weight. Tolerance or resistance: TMV, PVY, TEV, Ys.

Mint Star (C). The strong and open growing plant produces very attractive, medium sized, 12 cm x 10 cm fruit with high production. The blocky fruits mature from a bright mint green to yellow. Tolerance or resistance: TMV.

Olympian (Y). Maturity from transplant is 9 to 12 weeks. Half-long, hybrid bell, dark green turning golden yellow, three to four-lobed, 13 to 16 cm x 9 to 10 cm. Quality fruit with prolific yield. Can be harvested green or gold.

Orange Grande (C). This hybrid takes 76 days from transplanting. Deep, 15 cm x 14 cm version of Oriole. Ripens dark green/orange. Tolerance or resistance: TMV.

Orange Star (C). This hybrid variety takes 70 days from transplanting. Specialty market will rave about the colour and shape of this capsicum. The fruit start glossy green and then mature to rich scarlet orange while maintaining their firmness. Very heavy, blocky shaped fruit, good size, 12 cm x 12 cm. Tolerance or resistance: TMV, Ys.

Oriole (C). This hybrid takes 74 days from transplanting. Good sized, 14 cm x 12 cm, blocky, four-lobed fruit, which may be harvested dark green or mature tangerine-orange. Tolerance or resistance: TMV.

Premier (Y). Maturity from transplant is 10 to 12 weeks. Half-long, three to four-lobed, dark green turning red hybrid 14 to 16 cm x 10 to 11 cm. Thick walls and high productivity. Bush provides good sunburn protection.

Primebuster (C). This hybrid takes about 78 days from transplanting. Fruit is green to red, a deep, blocky bell capsicum that offers an exceptional disease resistance package. Its large, dark green fruit mature good colour on a medium plant and have held their size potential over multiple harvests. Good size, average 15 cm x 12 cm. Tolerance or resistance: Bls1,2,3, TMV, PVY1, PMMV.

Purple Star (C). This variety takes 75 days from transplanting. Good sized, blocky capsicum with thick-walled, three to four-lobed fruit. The fruit is shiny dark purple later turning dark red. Very early production, good size fruit 15 cm x 12 cm.

Raptor (CP 397) (N). Mid-season, strong and vigorous hybrid with a plant height between that of Target and Clovis. The plant produces medium to large leaves that protect the fruit and is concentrated in its fruit setting. Elongated, green to red fruit 14 cm x 9.5 cm. Mainly three to four-lobed fruit have straight sides and do not distort easily. During cool growing conditions the fruit may shorten to 12 cm, but maintain a uniform quality. Wall thickness is 5 mm plus. Suited for fresh market, open field and shadehouse/plastic trained culture. Tolerance or resistance: TMV, Ys.

Rex (CP 462) (N). Tall and vigorous hybrid with large leaves, 85 days from transplant. Good fruit cover. The flowering is continuous and the sets are predominantly on the outside of the stems, producing a lower amount of distorted fruit. Medium blocky, three to four-lobed, predominantly four-lobed fruit. The fruit are 12 to 13 cm long but can shorten to 10 to 11 cm in cool conditions. Fruit are green turning red with a quick colour change and have very good firmness and final red. Walls are 7 to 9 mm thick. Suited to fresh market and processing. Tolerance or resistance: TMV, Ys.

Rialto (H). Lamuyo type, sweet capsicum hybrid with very thick walls. Rialto is a long, blocky capsicum 12 to 17 cm x 8 to 10 cm. It is an early to mid-season fresh market type, with a semi-determinate bush, which provides cover to the fruit. Rialto yields very well and is particularly suited to multiple harvesting.

Rocky (CP 616) (N). Tall and vigorous hybrid with large leaves giving good fruit cover. The flowering is concentrated and early, 82 days from transplant. Blocky, three to four-lobed, predominantly four-lobed. Fruit is 11 to 12 cm long but can shorten to 9 to 10 cm in cool conditions. Fruit are green turning red and have excellent firmness and final red. Walls are 8 to 10 mm thick. Fruit have been shown to hold on the plant for an extended period at red with very little fruit loss, subsequently yield at red harvest can be dramatically improved. Suited for fresh market and processing.

Rubix (LV). High yielding, blocky hybrid. Compact plant. Firm, thick-walled, red fruit. Very strong against disease. Tolerance or resistance: TMV, Bls1,2,3.

Senator (Y). Maturity from transplant is 10 to 12 weeks. Long, bell hybrid, green turning bright red, three to four-lobed, 15 to 17 cm x 9 to 10 cm. Large fruited variety suitable for open field or protected culture.

Sienor (CLX 1498) (LV). An improved Heldor/Golden Gem type hybrid. Plants are slightly taller and more vigorous than Heldor. Strong vigour, with good cover gives fruit more protection and less sunburn. Green-yellow, 15 cm x 9 cm fruit are slightly larger than Heldor, weight 220 g, with improved uniformity and shape. Fruit are very firm with thick walls for prolonged shelf life. Tolerance or resistance: TMV, PVY.

Sundance (SPS 845). One of the first commercial hybrid yellow capsicums tolerant of bacterial spot. Shorter bush than Merlin with larger fruit and brilliant uniformity. Large, blocky fruit are four to five-lobed with very thick wall. Good firmness retained to full maturity. Good setting ability under higher temperatures, making this an excellent option for early and late harvests. Tolerance or resistance: Bls.

Target (CP 089) (N). Medium early hybrid, especially under cool growing conditions 80 days from transplant. Medium tall plant with sturdy habits (little or no lodging) and good leaf cover. Target reacts well to increased fertiliser application in the early establishment phase of growth. Large, elongated, green to red fruit with a tapered/blocky base has a quick colour change at maturity. About 10 cm x 15 cm, thick-walled, averaging 5 mm plus and a weight of 200 g. Concentrated setting, yield can be very high and subsequently there may be the possibility of some pinched fruit, but this generally only occurs in the first pick. Picks very easily. Very adaptable, suited for fresh market and processing. Tolerance or resistance: TMV, PVY, TEV, Ys, some field tolerance to bacterial spot and speck.

Tasty (CP 319) (N). Mid-season hybrid, 72 to 80 days from transplant, medium to strong vigour. Plants have good foliage and a short internode distance, producing very high yields. Medium blocky shape, 11 cm x 10 cm, with three to four lobes. Good firmness with relatively quick colour change from green to red. Plants are sturdy and tolerate prolonged harvesting without significant damage to the plant through breakage. Suited to fresh market and export and indoor and outdoor culture. Tolerance or resistance: TMV3.

Toledo (SPS). This Aries type hybrid has been outstanding in trials throughout Australia. The strong plant produces high yields of medium to large, four-lobed, three-quarter long fruit with very firm thick walls, glossy red and good uniformity. Good leaf cover with excellent ratoon cropping. Offers similar red quality and shelf life as Merlin with larger fruit size. Tolerance or resistance: Bls1,2,3, TMV, PVY, TEV.

Treasurer (Y). Maturity from transplant is 10 to 12 weeks. Long, three to four-lobed, green turning red hybrid 15 to 17 cm x 8 to 10 cm. High quality, elongated, bell-shaped fruit. Excellent colour and reliable size. Gaining favour across southern Australia due to its adaptability to the stresses and diseases of protected cropping.

White Star (C). This early setting hybrid variety takes 70 days from transplanting. The three to four-lobed fruit mature from an ivory white to light red. The medium strong, compact plants produce very attractive good sized, 15 cm x 12 cm fruit.

Yellowstone (H). Long, blocky, thick-walled hybrid. Fruit are uniform, three to four-lobed and about 15 cm x 8 cm. Medium sized, vigorous plant which is mid to late maturing. Tolerance or resistance: TMV.

Zafiro (RZ). Lamuyo type for late summer planting, and autumn winter harvest. Plants are vigorous and have an open habit. Internodes are longer than with the blocky types. Long, blocky fruit are large, 12 cm x 16 cm, average fruit weight of 250 g under good conditions but smaller under low temperature conditions. Suitable for both green and red harvesting. Also suitable for outdoor crops. Tolerance or resistance: TMV.

Zirconio (35-46) (RZ). Lamuyo type for spring, summer and autumn crops. Earlier than Zafiro and highly productive. The plant is longer and the deep red, glossy fruit are slightly smaller than Zafiro, average fruit weight of 230 g. The fruit wall is very thick. Tolerance or resistance: TMV2.

Long, sweet, yellow capsicums

Banana Supreme (C). An early, sweet, banana type hybrid that produces a concentrated set of long, medium thick, non-pungent, sweet, yellow chillies. Its medium sized plant is vigorous and has a very high, field yield potential. It is a star performer in the processing industry and is also ideally suited for the fresh market.

Cutlass (SPS 966). Improved, Long Sweet Yellow, banana type with larger size and length. The fruit have a smooth, attractive appearance featuring thick walls and straighter sides, and retain excellent firmness through to red stage. More open plant habit with excellent yield. Offers growers a new quality level in 'Hungarian Yellow' fruit production.

Fiesta (SPS 815). Early maturing, large, sweet, yellow banana type. The two to three-lobed fruit are yellow turning red, with medium thick walls. This variety has a high yield potential and is ideal for fresh market or processing.

Hombre (SPS 959). A sister line to Cutlass, this improved Long Sweet Yellow banana type features a more open plant habit with excellent yields. Bears straighter-sided fruit with thick walls and excellent firmness through to red. Higher quality with smoother, more attractive appearance over the current standards.

Long Sweet Yellow (SPS). The standard for many years, this sweet, yellow, wax type features long tapered fruit 15 to 18 cm x 4 cm. Yellow turning red with high yield potential.

LV 7240. Hungarian Sweet Yellow Wax type hybrid. Long straight fruit with good holding ability. Average fruit length is 20 cm. Fruit are dense with good weight. Fruit turn from yellow-green to red.

Pirola (LV 222). An improved Hungarian Sweet Yellow Wax type hybrid. Superb long and very straight fruit. Plants are erect and early to mature. Fruit are 20 to 22 cm long and hold their quality and shape well. Fruit are yellow-green turning to red.

Slatki (SPS). Sweet, yellow banana type with light green to yellow fruit 20 to 22 cm long. Strong plant with early maturity, well suited for both indoor and outdoor cultivation.

Spanish Sweet (C). Early, productive, extra long hybrid Italian type. The straight fruit are 25 cm x 5 cm and weigh about 140 g. Plant is erect with medium tall habit and short internodes. The dark green fruit ripen early to a dark crimson red. Fruit is sweet with a full sweet chilli flavour and really expresses well in sauces and fried preparations. Tolerance or resistance: TMV.

Super Sweet Banana (C). One of the earliest sweet banana types, with much larger, up to 20 cm, heavier fruit with thick walls and sweet flavour. Fruit are tapered with heavy shoulders and ripen to a light butter colour.

Yellow Classic (C). This hybrid variety takes 60 days from transplanting and produced one of the top yields in our trials of the banana chilli types. An early version of the Super Sweet Banana, with slightly longer, 21 cm, straighter, golden fruit which mature dark red. Yellow Classic is a star performer for marketing and processing because it has thick flesh and stays crisp and sweet after processing.

Yellow Robust (C). This hybrid is our first banana type chilli with resistance to bacterial spot, something banana chilli growers have been looking for. The plant is medium height with nice smooth, glossy, large, 20 cm x 5 cm fruit and thick walls. Tolerance or resistance: Bls 1,2,3.

Yellow Tunnel (C). This hybrid variety takes 56 days from transplanting. The world's earliest maturing yellow banana chilli. Large, smooth pendant, thick-walled, 23 cm, tapered, buttery yellow, average 6 to 8 cm at the shoulder. Very high sugar taste and productive.

Hot chillies

Birdseye types

Bithot (F). True birdseye type, more than a bit hot. Very prolific bush, exceptional yields. Labour intensive.

Inferno (Y). Maturity from transplant is 7 to 9 weeks. Large, birdseye type hybrid. Short, tapered, 4 to 6 cm x 1.5 cm fruit, green turning red.

Compact bush suitable for high density plantings. Prolific bearer of attractive and very hot fruit. The variety of choice by wholesalers.

Cayenne types

Ballistic (SPS 981). Red, cayenne type hybrid which offers an excellent alternative to SPS 770 for commercial processor and fresh market production. Consistently hotter in trials, the clean, smooth, uniform fruit are slightly longer than that of SPS 770, about 15 to 16 cm x 1.2 cm, with medium thick walls and firm skins. A more compact plant, has a dense habit for excellent fruit protection with good disease tolerance.

Cayenne King (LV). A hot, cayenne type hybrid producing high yields. Fruit are large and taper to a point. Fruit are green maturing to a rich, glossy red.

Caysan (SPS 705). High quality, high yielding, hybrid cayenne type which offers excellent quality for fresh market use. Early maturity of smooth tapered fruit, 130 mm x 10 to 15 mm, medium thick walls. Dark green, mature fruit, quickly turning red.

Chain Fair (C). Tall plant, vigorous growth, this hybrid is resistant to virus disease. The smooth surfaced fruit are long, 17 to 20 cm, and slim, 1.6 cm in diameter, and weigh about 18 to 22 g, with flesh about 0.2 cm thick. It is very pungent (hot) and is suitable for fresh market, frying and seasoning use.

Childers (H). High yielding, vigorous, tall bushed hybrid with attractive lime green fruit and very smooth skin. Thick-walled, glossy cayenne type. Fruit are about 13 cm x 2.5 cm, highly pungent and weigh about 18 g.

Cluster (SPS). Interesting cayenne type with excellent harvest potential. Tapered green turning red fruit, 60 to 70 mm x 10 mm, are bunched in ‘hands’ for easy harvest. Proven popular fresh market hybrid for use with bedding plants and home garden markets.

Diablo (Y). Maturity from transplant is 9 to 11 weeks. Long, tapered, very hot hybrid 13 to 14 cm x 2 cm, green fruit turning attractive glossy red at maturity.

Firefly (SPS). The green fruit turning red are about 8 to 9 cm x 1 to 1.5 cm, smooth and tapered. The hardy, hybrid plants are abundant producers of small, hot cayenne type chillies for the fresh market and provide good protection for the fruit.

Laser (H). Very high yielding, cayenne type hybrid with thick-walled, heavy, glossy fruit, which turn from green to a very attractive red when fully mature. The bush provides good cover for the 12 to 15 cm long, semi-pungent fruit.

Long Mexican (C). This hybrid variety takes 73 days from transplanting. The ideal pepper for the ‘perfect’ salsa intensity—not too hot, not too mild. Featuring a medium pungency rating, the extra smooth, 18 to 20 cm long fruit have medium thick walls tapering to a point. The large plants bear heavy yields of dark green fruit, which turns red at full maturity. A hot Mexican type.

Long Red Cayenne Slim (Y). Maturity from transplant is 9 to 11 weeks. Long, tapered, open pollinated variety, 10 to 11 cm x 2 cm, green turning red. Medium spicy, fruit slightly twisted. Suitable for fresh market and processing.

Long Red Cayenne Thick (Y). Maturity from transplant is 9 to 11 weeks. Long, tapered, open pollinated variety, 10 to 11 cm x 2 cm, green turning red. Medium spicy, fruit slightly twisted. Suitable for fresh market and processing. Very productive.

Long Zippy (C). Hybrid plants are erect, tall and very vigorous. Fruit are long, 18 cm, and slim, 2 cm, diameter on average. Medium green fruit turns bright red at maturity, with smooth, thin walls, medium pungency. Good for fresh market and drying.

NW 45 (Y). Maturity from transplant is 9 to 10 weeks. Medium length, tapered 10 cm x 1.5 cm green to red. Slim cayenne type hybrid suitable for fresh market or processing for paste or powder. The fruit are attractive and very hot.

Red Hot® Glory (H). Extremely vigorous and prolific, high yielding, green, cayenne type hybrid with fruit 15 cm x 1.5 cm and weighing about 8 g. Red Hot® Glory has very high pungency, is suitable for extended picking and has a bush height of 40 to 45 cm.

Scorpion (Y). Maturity from transplant is 9 to 10 weeks. Long, thick, tapered hybrid, 14 to 16 cm x 1.5 to 2 cm, dark green fruit turning red. Large, thick, cayenne style suited to fresh market or processing.

Shady Lips (C). This hybrid has early maturity and high yields. Attractive 18 cm x 1.6 cm fruit has thick walls and smooth skin. Deep red mature fruit and high pungency allow for good processing quality. Tolerance or resistance: *Phytophthora capsicum*.

SPS 770. This hot hybrid is well suited to commercial processor chilli production and fresh market. Plant habit is more upright than Caysan with similar fruit numbers but offers earlier maturity and improved uniformity. Fruit are slightly shorter than Caysan with improved heat levels. The calyx is easy to remove and the thinner walls are ideally suited to processing. This offers a better response to ethylene and a much better recovery of full red fruit, which, in turn, offers a better suitability to mechanical harvest.

Volcano Improved (CP 431) (N). Maturity is about 12 weeks from transplanting or 16 weeks from seeding when picking at red stage. Green turning red, hybrid cayenne type. Tall, upright, sturdy bush with excellent leaf cover and very strong vigour. Fruit are held up off the ground. Straight pedicel. Fruit are borne pendulously, and are predominantly straight, averaging 13 to 14 cm x 1 to 1.5 cm across the top, tapering to a pointed end. Average wall thickness is 2 mm, with firm flesh texture. Very hot, even through difficult colder conditions. Fresh market and processing, machine harvests well, with calyx easily detached. Tolerance or resistance: Bls.

Wildfire (CP 264) (N). Mid-season 68 to 72 days from transplant. A medium-tall growing, hybrid short cayenne, the plant tolerates lodging very well and holds fruit well up in the plant structure which enables easy harvesting. Leaves are small but numerous, offering good fruit protection. Long and tapered fruit 7 cm x 2.5 cm and 2 mm thick walls. Fruit change colour from dark green to bright red and may be hot even from a reasonably immature stage. For growing in open fields. Suited for fresh market and processing

Habanero types

Habanero (SPS). By far the hottest chilli type hybrid available with a Scoville rating of up to 200 000. Fruit are a wrinkled, pointed, bell shape, 2.5 cm x 5 cm, with a light green thin wall turning orange-pink at maturity. Later to mature, 90 to 100 days from transplant, with moderate yields of extremely pungent fruit. Although suited to fresh market, it is often used for paste and sauce, or oil extraction for blending to add heat to other chilli mixes.

Hot yellow types

Blister (SPS 641). Attractive hybrid, hot, Hungarian wax type, yellow turning red at maturity. High yields of medium thick-walled uniform fruit. The large, smooth fruit have a tapered banana pendant shape about 20 cm x 2 to 3 cm.

Cascabella (SPS 807). This open pollinated line produces tapered, conical fruit, 3 cm x 3.5 cm, with a blunt end. Fruit are yellow turning orange-red at maturity, with extremely high pungency. The moderate plant is early to mature, 72 to 75 days from transplant, and features an erect habit and moderately high yields. Suited to fresh market and pickling, the small hot fruit can reach top market prices with excellent quality and uniformity.

Fury (F). Dwarf plant with long hot fruit to 180 mm. Yellow, orange and red in a vivid prolific display of colour. Red is particularly hot.

Lorena (LV 223). A very hot, yellow, wax type hybrid. Strong, erect, early maturing plants. Fruit are light green to red, long and straight, 20 to 22 cm x 3 cm. Suited for both indoor and outdoor production.

Lutjirog (SPS). Hybrid, hot yellow, banana type, pale green turning yellow, 18 to 22 cm long.

Nour (LV). A hot, green-yellow, wax type hybrid. Very early maturity with medium vigour. Fruit are 21 cm x 2 cm and weigh 80 g.

Jalapeno types

Hotlips CP 387 (N). Mid-season hybrid 68 to 72 days from transplant. Tall growing, the plant tolerates lodging very well and holds fruit well up in the plant structure, enabling easy harvesting. Leaves are small, but due to the high volume offer good fruit protection. Fruit is conical, 7 cm x 2.5 to 3.5 cm, with 3 mm thick walls. Fruit change from dark green to bright red and are hot, even from a reasonably immature stage. Before the green stage the fruit may show a characteristic dark purple/black but this is due to temperature. As the fruit mature they lose this colouring and continue the standard colour changes. Very hot, even under low light conditions. Fruit exhibit some skin cracking associated with standard Jalapenos but to a much lesser degree. Suited to open field production for fresh market and processing.

Jalapeno (Y). Maturity from transplant is 9 to 11 weeks. Conical, short, blunt, 4 to 5 cm x 2 cm dark green fruit. Very hot and productive hybrid. Preferred chilli for Mexican dishes.

Largo (SPS 7-203). Hybrid, which offers larger size and smoother flesh. Very high yield potential with excellent uniformity. Consistently produces fruit 2.5 to 3 cm x 1 to 1.5 cm, larger than Mitla.

Mitla (SPS 637). Slightly tapered hybrid with rounded ends, 70 to 80 mm x 25 mm. Green fruit are smooth and attractively coloured while the mature red fruit have the characteristic growth cracks (common to the Jalapeno type) on the outer skin. Early maturity and high yields with very easy harvesting, each fruit weighs up to 45 g. Excellent, original, very hot, Mexican flavour.

Tampico (C). Vigorous hybrid plants produce large, 10 x 14 cm, cylindrical, thick-walled fruit that mature from dark green to shiny red. The plant continues fruiting for long period. Tolerance or resistance: TEV, PVY.

Miscellaneous types

Hot Dipper (C). This hybrid variety takes 70 days from transplant. The thin, elongated fruit are 6 cm x 1.5 cm, with blunt tips and thick walls. The vigorous plants set the dark green to red fruit pendently. These large fruit pick faster than regular Serrano types. This is sure to be the hottest seller for the fresh market.

Hotline (F). Thin-walled fruit, 180 mm x 20 mm. Grows green to bright red with medium pungency at maturity. Plant is tall and very prolific.

Inferno (F). Thick flesh, green to red fruit, 150 mm x 25 mm. Very pungent.

Nitro (SPS 7-202). Matures 75 to 80 days from transplant with continuous set. Hot, Serrano type hybrid with slim, club-shaped fruit for the pickling and sauce market. Fruit are green turning red, 6 cm x 1 cm, with medium thin walls. Erect branching habit offers good cover and fruit protection.

SPS 760. This early maturing, hybrid line produces extremely attractive, pendant, 'cherry' globed fruit. Ideal for pickling, the fruit are green turning red, with moderate heat, thick walls, good uniformity and a long shelf life. Plants are high yielding and very easy to harvest.

SPS 823. Early maturing, hybrid paprika type with characteristic thin walls and high colour. Long, tapered fruit are dark green turning dark red. Particularly well suited to dehydrating and colour extraction markets. The strong plant is early maturing and suited to both indoor and outdoor production.

Super Chilli (C). This hybrid variety takes 75 days from transplanting. Super Chilli is an attractive ornamental quality fruit bred for exceptional yields. The abundant, 6 cm fruit are borne upright on the plant and held above the foliage. Colourful fruit ripen from medium green to red.

Planting times

Table 5 shows the varieties grown and Table 6 shows the main planting and harvesting times for the main production districts. Harvesting green fruit usually starts 10 to 12 weeks after transplanting, and a further two to three weeks later for red fruit, depending on variety and temperature.

Table 5. *The main varieties grown in each district*

District	Main varieties	
	Capsicums	Chillies
Bowen	Aries, Merlin, Target	Caysan, Firefly, Inferno, Long Cayenne
Bundaberg	Aries, Belair, Blockade, Eclipse, Merlin, Raptor, Rex, Target	Cayenne, Caysan, Habanero, Hotline, Inferno, Inferno Birdseye, Long Zippy
South-east Queensland	Aries, Merlin, Target	Inferno, Jalapeno
Granite Belt	Merlin, Heldor, Target	Banana Supreme, Long Sweet Yellow

Table 6. *Main planting and harvesting times*

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

Capsicum nutrition

Adequate plant nutrients are necessary to produce high yields of good quality fruit. The most critical nutrient in capsicum 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 do a soil analysis of what elements are available 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 guesswork 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 crop's growth pattern, 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. Capsicums 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. Figure 4 shows how soil pH affects the availability of nutrients; the width of the band shows nutrient availability at different pH levels.

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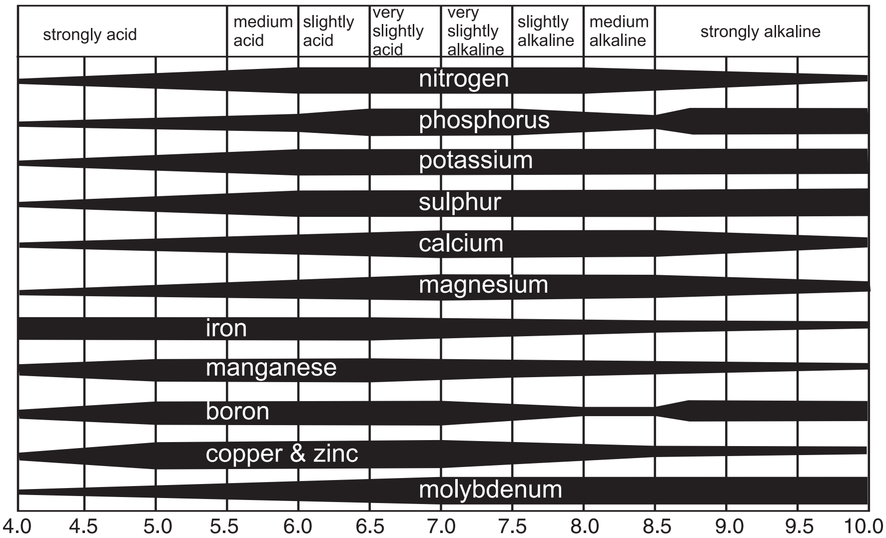

***Figure 4.** Nutrient availability at different soil pH levels*

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	Sandy loam	Loam	Clay loam
pH range	t/ha	t/ha	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, magnesium and pH in the soil*

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		✓		✓		✓		

Capsicum nutrition

Capsicums 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 fruit.

Table 9 shows the approximate amount of nitrogen, phosphorus, potassium, calcium, magnesium and sulphur, averaged over spring and autumn, that capsicum crops can be expected to remove from the soil. Remember that the elements in the stems, leaves and roots will be returned to the soil when the crop is ploughed in.

Table 9. *The amount of nutrients removed from the soil by an average capsicum crop*

	Amount of element removed in kg/ha					
Nutrient	N	P	K	Ca	Mg	S
Plant (stems, leaves, roots)	94	8	128	72	32	19
Fruit	98	13	80	5	8	11
Total	**192**	**21**	**208**	**77**	**40**	**30**

Major elements

Nitrogen (N)

Nitrogen is required for plant growth and vigour. Plant size, leaf area and the number of flowers produced are dependent on an adequate supply of nitrogen. Insufficient nitrogen will result in poorly grown, pale or yellow plants, low yields and small, pale green fruit. Large amounts of decomposing matter can induce nitrogen deficiency, and then result in high nitrogen levels when decomposition is complete. If excess nitrogen is available to the plants, fruit set and quality will be poor and fruit will be soft. Nitrogen is easily leached from the soil by excess rain or irrigation.

Phosphorus (P)

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. Deficiency occurs in red or brown soils high in iron (Fe) and aluminium (Al). Phosphorus is not readily leached from the soil.

Potassium (K)

Adequate potassium is required to produce high quality fruit. A good supply of potassium improves fruit shape, colour and firmness. Leaves of potassium deficient plants develop greyish margins which may turn brown. Ashen grey-green leaves at the base of the plant may be the first indication of deficiency, followed by leaf speckling and necrotic areas. Fruit may ripen unevenly. Deficiencies can occur in sandy soils, acidic soils below pH 5.4, and alkaline soils above pH 7.5. Potassium is leached from the soil by excess rain or irrigation, but not as easily as nitrogen.

Calcium (Ca)

Calcium deficiency may occur in acidic soils and leached or poorly structured soils. Shoot growth is restricted and the growing points may die. It is associated with blossom-end rot of fruit and has also been implicated with the fruit-spotting condition called Yolo spot (also known as pitting, stip or green spotting). For reasons not well understood, plant deficiency can occur in soils with adequate levels of calcium present. Uneven soil moisture and poor quality water increase the severity of the problem. Apply lime, dolomite or gypsum as recommended by the soil analysis. Foliar sprays of calcium nitrate $(Ca(NO_3)_2$ 200 g/100 L applied when fruit are very young may reduce blossom-end rot and improve fruit quality.

Magnesium (Mg)

Magnesium can be deficient particularly in high rainfall areas and where soils are fairly acid. High levels of calcium and potassium can also make magnesium unavailable. Apply dolomite or spray with magnesium sulphate ($MgSO_4$) on the soil as recommended by the soil analysis. If pre-plant soil treatment with dolomite was inadequate or where high rates of potassium nitrate are used through trickle irrigation, foliar sprays of magnesium sulphate (2 kg/100 L) can be applied to correct deficiencies. Application through the irrigation system at about 20 kg/ha can be used, but calcium in irrigation water may react with sulphates and cause precipitation in trickle tubing. Yellow mottling between the veins of older leaves is a symptom of magnesium deficiency.

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.

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 below. 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 (B)

Boron deficiency is more likely in sandy neutral to alkaline soils, particularly in cold weather or if soils have recently been heavily limed or are low in nitrogen. Fruit may have cracked or corky areas similar to wind rub.

If boron is deficient, spray 5 kg/ha of Solubor on 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 (Mo)

Molybdenum deficiency is more common in soils below pH 6.0. Older leaves become mottled and may curl in and die back from the tip. 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 (Zn)

The availability of zinc decreases at pH levels above 7.0 and below 5.0. High phosphorus levels and wet or cold conditions can induce zinc deficiency. Leaves yellow between the veins and may be small, resulting in the term 'little leaf' for zinc deficiency. Soil applications are the most effective way to control this deficiency. Applications may be broadcast over the entire area or banded in the rows at rates up to 10 kg/ha of zinc. The higher rates may remain effective for several years. Zinc may also be applied to the crop as a foliar spray if required.

Soil applications are best made using zinc sulphate monohydrate (35.5% Zn). Zinc sulphate heptahydrate (22.7% Zn) can be dissolved in water and sprayed on the soil using a boom spray or injected through the trickle irrigation system.

In the nursery and after planting, apply zinc sulphate heptahydrate (100 g/100 L) or zinc chelates if a deficiency becomes apparent.

Table 10 shows application rates for boron, molybdenum and zinc.

Table 10. *Application rates for boron, molybdenum and zinc*

Element	Product	Rate	Comments
Boron	Solubor	5 kg /ha 200 g/100 L	Spray on the soil. Foliar spray. Solubor is NOT compatible with zinc sulphate heptahydrate.
Molybdenum	sodium molybdate	60 – 100 g/100 L	Spray in the nursery and again about three weeks after transplanting.
Zinc	zinc sulphate monohydrate	10 – 20 kg/ha	Spray on the soil three weeks before planting and work it in.
	zinc sulphate heptahydrate	20 – 30 kg/ha 100 g/100 L	Spray on soil or apply through the trickle irrigation. Foliar spray. Do not mix with boron.

Fertilisers

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 13:15:13 contains 13 kg nitrogen, 15 kg phosphorus and 13 kg potassium.

Fertilisers should be applied before planting (pre-plant) and as side dressings (post-plant) as the crop grows. The fertiliser program should be based on soil, leaf and sap analysis. For a fertile soil the minimum rates to apply are 30 kg of nitrogen (N), 30 kg of phosphorus (P) and 40 kg of potassium (K) per hectare. Table 11 shows a range over different soil fertility for the total requirements of the major elements nitrogen, phosphorus and potassium to grow a capsicum crop.

Table 11. *The total requirements of the major elements in kg/ha*

Application	Minimum (fertile soil)			Average soil			Maximum (infertile soil)		
	kg/ha			kg/ha			kg/ha		
	N	P	K	N	P	K	N	P	K
Pre-plant (basal)	30	30	40	45	50	60	60	100	100
Post-plant (side dressing)	30	0	20	90	5	90	120	10	100
Total	**60**	**30**	**60**	**135**	**55**	**150**	**180**	**110**	**200**

Pre-plant (basal) fertiliser

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

Pre-plant fertiliser requirements are best determined from the results of a complete soil analysis. If a soil analysis is not used, apply a pre-plant fertiliser which will supply about the following rates: 45 kg of nitrogen (N), 50 kg of phosphorus (P) and 50 kg of potassium (K) per hectare. For a fertile soil the minimum rates to apply are 30 kg of nitrogen, 30 kg of phosphorus and 40 kg of potassium per hectare. Table12 shows fertiliser rates and element supplied for two common N:P:K mixtures. Apply fertiliser in a band or incorporate within the plant rows.

Table 12. *Fertiliser rates and element supplied for two common N:P:K mixtures*

N:P:K mixture	Quantity to apply		Element applied (kg/ha)		
	kg /ha	kg /20 m of bed	N	P	K
5 : 6 : 5	900 – 1000	2.7 – 3	45 – 50	54 – 60	45 – 50
13 : 15 : 13	350 – 400	1.1 – 1.2	46 – 52	53 – 60	46 – 52

On high phosphorus level soils use a 15:4:12 or similar mixture. Other elements that are required in relatively large amounts include calcium, magnesium and sulphur.

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Using these products
Table 8
This section page 38

Sulphur does not usually need to be applied separately as it is 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.

Apply the pre-plant fertiliser to the soil surface in a 60 cm wide band and incorporate with a rotary hoe during final soil preparation or bed-forming. In soils where phosphorus may be tied-up (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 5).

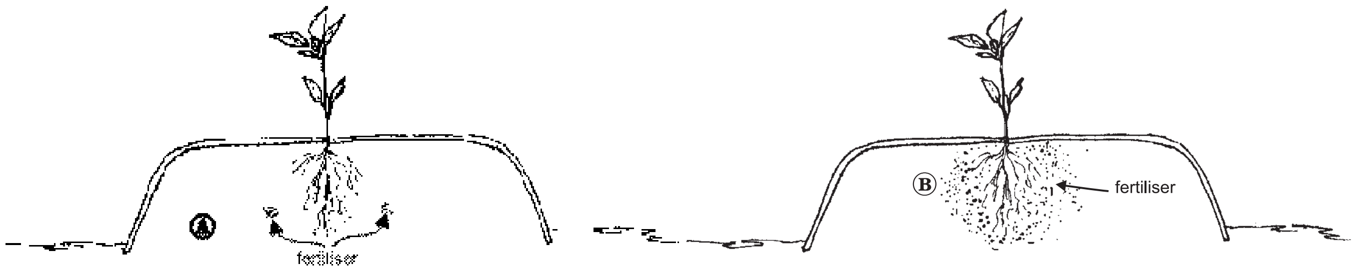

Figure 5. *Pre-plant fertiliser, drilled (A) and banded (B)*

Monitor plant nutrients and fertilise

The pre-plant fertiliser will generally allow the crop to grow 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 and through lateral leaching from the interrows. It may increase the availability of nutrients that had been previously washed to the outsides of the beds.

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 14 is a guide to additional 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 13. Use the results of soil and leaf testing to refine the fertiliser schedule for the next crop. Do a leaf analysis at early fruiting. Buy a tissue sampling kit from your farm supply outlet and follow its instructions. The laboratory analysing your sample will interpret your results. The optimum levels for the youngest fully mature leaf taken when the first fruit mature are shown in Table 13.

Table 13. *Optimum leaf nutrient levels (based on dry weight)*

Nutrient	Normal level
Nitrogen (N)	3.0 – 5.0%
Phosphorus (P)	0.3 – 0.6%
Potassium (K)	3.0 – 5.5%
Calcium (Ca)	1.0 – 3.5%
Magnesium (Mg)	0.25 – 1.2%
Sodium (Na)	0 – 0.3%
Chloride (Cl)	0 – 1.6%
Copper (Cu)	10 – 200 ppm
Zinc (Zn)	20 – 100 ppm
Manganese (Mn)	26 – 300 ppm
Iron (Fe)	60 – 300 ppm
Boron (B)	30 – 100 ppm
Molybdenum (Mo)	0.5 – 2 ppm

Source: Weir and Cresswell, NSW Agriculture, 1993.

Sap testing is a means of rapidly assessing a plant's nutrient status during crop growth. This test 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 or to correct any nutrient problems before yield or fruit quality are affected.

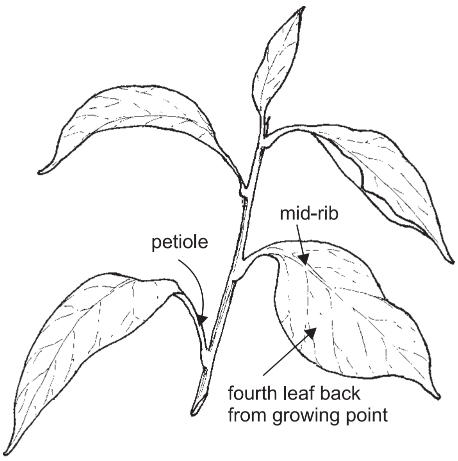

Figure 6. *For sap tests collect the youngest fully expanded leaf from the growing point*

Sap testing involves collecting leaf stalks (petioles) and the mid-rib 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 early budding and continue through harvesting for crops harvested over a long period. Figure 6 shows which leaf to collect. You can do the tests yourself, but we recommend you use a commercial sap testing service for the tests and advice 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.

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Sap testing services
Section 6 page 8

Apply side (post-plant) dressings

Leaf and sap tests are useful guides when deciding on side dressings and are usually available from the same laboratories as soil analysis. Up to 60% of nitrogen is usually applied before fruit set. See Tables 13 and 19 for the recommended levels. Table 14 gives a general guide to the additional amount of N:P:K to apply to the crop as side dressings.

Table 14. *Approximate additional N:P:K requirements in kg/ha*

Nutrient	Minimum (Fertile soil)	Average	Maximum (Poor soil)
Nitrogen (N)	30 kg	90 kg	120 kg
Phosphorus (P)	0 kg	5 kg	10 kg
Potassium (K)	20 kg	90 kg	100 kg

Fertilising through irrigation water (fertigation)

In Queensland practically all capsicum crops are grown using trickle irrigation. 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.

The fertiliser schedule used should be based on the results of soil, leaf and sap tests. If these tests are unavailable, Table 15 is a guide to fertigating capsicums. Higher rates may be required on poor soil, while lower rates could be used on fertile soil.

Table 15. *A guide to fertiliser application through trickle irrigation*

Weeks from planting	Fertiliser (kg/ha)	Rate	Comments
Weeks 2 and 4	Calcium nitrate Mono ammonium phosphate	20 15	Do not mix calcium-based products with phosphorus-based products
Week 5 (or early fruit set)	Calcium nitrate Ammonium nitrate	30 10	
Weeks 6 – 11 (up to first harvest)	Calcium nitrate Ammonium nitrate Potassium nitrate	30 10 20	
Weeks 12 – 15 + (during harvest)	Potassium nitrate	30 – 40	

The fertiliser rates suggested here are for use on a soil of average fertility and when soil and sap test results are not available. If 350 kg/ha of a 13:15:13 mix is applied as a basal application, followed by the rates of fertilisers in Table 15 applied over a 12-week growing period and four-week harvest, a total of 146 kg of nitrogen, 61 kg of phosphorus and 146 kg of potassium will be applied per hectare. Table 16 shows the total amounts of fertiliser applied.

Table 16. *Total amount of fertiliser applied per hectare*

Fertiliser	Applications		Rate	Sub-	Total
	Timing	No.	/ha	total	
13:15:13 (N:P:K mix)	Pre-plant	1	350	350	**350**
Mono ammonium phosphate (MAP)	Weeks 2 and 4	2	15	30	**30**
Ammonium nitrate (NH_4NO_3)	Early fruit set to first harvest	7	10	70	**70**
Calcium nitrate ($Ca(NO_3)_2$)	Planting to early fruit set	2	20	40	
Calcium nitrate ($Ca(NO_3)_2$)	Early fruit set to first harvest	7	30	210	**250**
Potassium nitrate (KNO_3)	Early fruit set to first harvest	6	20	120	
Potassium nitrate (KNO_3)	During harvest	4	35	140	**260**

Note: Overuse of potassium (K) and calcium (Ca) can induce magnesium (Mg) 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 ($MgSO_4$) to soils low in magnesium.

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 17. There is also a range of soluble commercial fertiliser blends.

Table 17. *Fertilisers that can be dissolved in water for fertigation*

Fertiliser	Main elements supplied	% of elements
Urea	Nitrogen	46% N
Calcium nitrate	Calcium, nitrogen	18.8% Ca, 15.5% N
Ammonium nitrate	Nitrogen	34% N
Potassium nitrate	Potassium, nitrogen	38.3% K, 13 % N
Potassium chloride	Potassium	50% K, 50% Cl
MAP (mono ammonium phosphate, technical grade)	Nitrogen, phosphorus	12% N, 26.6% P
MKP (mono potassium phosphate)	Potassium, phosphorus	28.6% K, 22.8%P

Side dressing overhead or furrow irrigated crops

The fertilisers and rates in Table 18 may be used if soil or plant test results are not available. The quantities per 20 m of bed are the same whether rows are single or double spaced. Drill into the irrigation furrow before watering for furrow irrigation. Drill or spread if using overhead irrigation.

Start fertiliser application three to four weeks after transplanting and repeat every three to four weeks until about two weeks before first harvest. For crops harvested over many weeks, for example chillies, further applications at half the rate in Table 18 may need to be applied.

Table 18. *A guide to fertiliser application for overhead or furrow irrigated crops*

Fertiliser	Rate per	
	kg/ha	g /20 m of bed
Urea	100 kg	300 g
Or		
Ammonium nitrate	150 kg	450 g
Alternated with		
15:4:11 or similar mixture	250 kg	750 g

Foliar fertilisers

Foliar fertilisers contain soluble nutrients which are sprayed on the crop and absorbed through the leaves. They may be urea or potassium nitrate dissolved in water, specific trace elements or a ‘shotgun’ mixture of many major and trace elements.

As the plant’s primary means of absorbing nutrients is through the root system, foliar fertilisers should not be used to replace soil applications. However where specific trace element deficiencies have been identified, or disease, nematodes or waterlogging have made the roots ineffective, foliar fertilisers may help the plants survive until new roots develop and can again support them.

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 midmorning 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 into the 20 mL calibrated jar and make up to the 20 mL mark with distilled water then 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 above 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 capsicums

Table 19 shows the optimum nitrogen and potassium sap levels for a capsicum crop. These levels can be affected by over or under watering and stressful conditions. Diagnose the cause of the low levels and then apply a suitable nutrient if necessary.

Nitrogen and potassium are the two most easily managed and influential nutrients in capsicums. Table 19 indicates the optimum range for these nutrients.

Table 19. *Optimum sap levels for nitrogen and potassium*

Nutrient	Level in milligrams per kilogram (mg/kg, ppm)					
	Bud development	Early flowering	Late flowering	Fruit set	Fruit growth	During harvest
Nitrate	4500	5000	4000	300	2000 – 2500	1000
Potassium	5000	5000	5000	5000	5000	5000

Figure 7 is a diagrammatic representation of optimum nitrogen sap levels at various stages of plant growth.

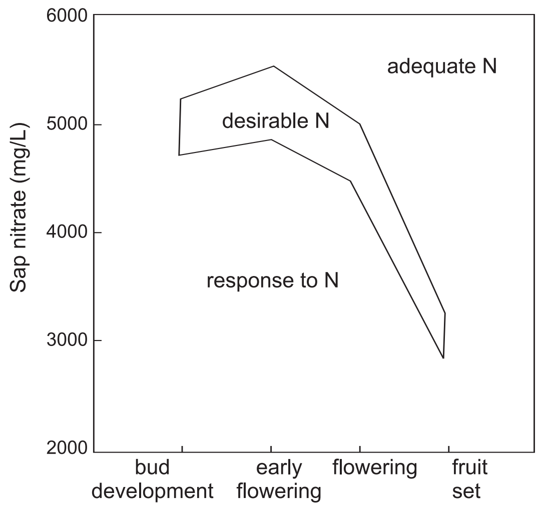

Figure 7. *Optimum sap nitrate levels in petioles*

Irrigation and water management

Irrigation management is one of the keys to producing a high yielding, good quality capsicum crop. When compared to many other crops capsicums have a shallow root system, so wasting water and leaching nutrients can easily occur. An efficient irrigation system and accurate scheduling is essential.

Water management to produce quality capsicums

The main quality control method is accurate irrigation scheduling. Inaccurate irrigation is the major cause of poor nutrition. Monitoring both gives you the best chance to achieve maximum profits. Most growers tend to over water in the early stages of the crop and leaching of fertiliser, in particular nitrogen from the root zone, is common and fertiliser is often wasted. Table 20 shows the symptoms of poor water management at different growth stages.

Table 20. *The symptoms of poor water management*

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 Predisposes plants to sudden wilt 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 Slow to mature Soft fruit Sudden wilt disease

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 irrigation method used in capsicums, but furrow and overhead irrigation are sometimes used.

Trickle irrigation

Trickle irrigation is the most easily controlled method. 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 21 shows the advantages and disadvantages of trickle irrigation.

Table 21. *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 growing period	Requires regular maintenance during the
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 that allows water to spread laterally without penetrating too deep into the soil. Table 22 shows the advantages and disadvantages of furrow irrigation.

Table 22. 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
	Poorer weed control
	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 23 shows the advantages and disadvantages of overhead irrigation.

Table 23. 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	Wets interrow and headland areas, promoting weed growth
	Spreads bacterial diseases
	Affected by wind
	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
	Difficult to 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 crops needs. This is known as a monitoring or scheduling system. The importance of monitoring is confirmed by research which shows that water use can be considerably reduced with 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 24.

Table 24. 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

Getting the best from your irrigation

To get the best from your irrigation system use a scheduling device, such as tensiometers or Enviroscan, 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 capsicums

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, without stressing plants, to encourage a bigger root system and root development down to 30 to 50 cm. This allows roots to access a larger volume of soil nutrients and moisture and may reduce the risk of sudden wilt. 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. Maintain even soil moisture.

Tables 25 and 26 show the optimum range for readings on the shallow tensiometer (15 to 20 cm) for the different stages of plant growth. Irrigate if the tensiometer reading is above the higher figure. If the tensiometer stays below 10 kPa the soil is too wet.

Table 25. Optimum range for shallow tensiometer readings from planting to early fruit set

Soil type	Tensiometer reading	
	Establishment	Up to early fruit set
Sandy loams	10 – 25	10 – 25
Clay soils	10 – 30	15 – 30

Table 26. Optimum range for 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	10 – 25
Clay soils	10 – 30	10 – 30

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 (kPa) (Figure 8). 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 orirrigation, water moves from the soil back into the tensiometer and gauge readings fall.

more info

Where to get this book
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The DPI has published a useful booklet—*Water it right: a guide to using tensiometers*.

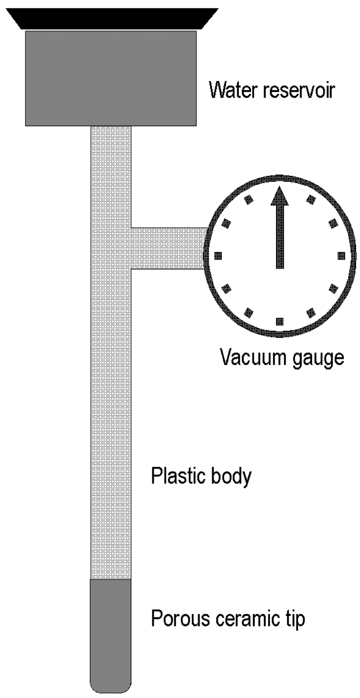


Figure 8. *Parts of a standard tensiometer*

A monitoring site consists of one shallow tensiometer installed in the major root zone and one deep tensiometer below most of the roots (Figure 9). 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 15 to20 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.

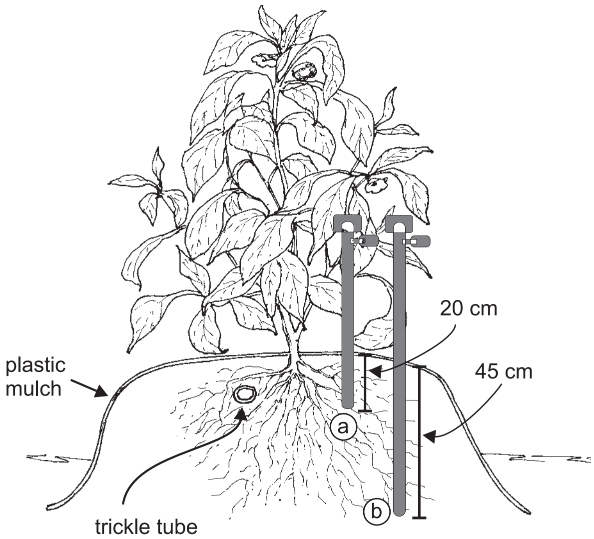


Figure 9. *Profile of a typical tensiometer monitoring site in capsicums*

The shallow tensiometer indicates when to water. The deep tensiometer 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 15 to 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 about $30 per tip, this can be an expensive lesson. If you reach a hard soil layer, take the tensiometer out and try somewhere else or use the deep tensiometer procedure.

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 tractors, harvesters, rotary hoes and other machinery may damage them.

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 crops were 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 10 shows diagrammatically how the tensiometer reacts to different amounts of irrigation whilst Figure 11 is a sample char with shallow and deep tensiometer readings plotted over several irrigations.

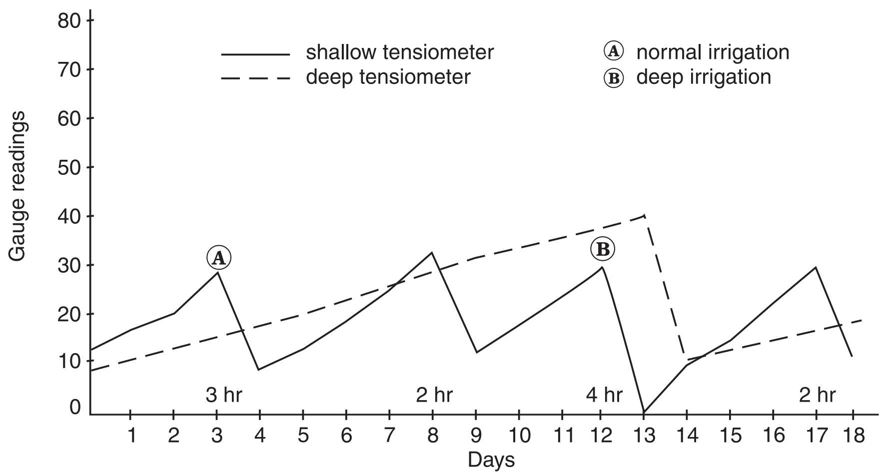


Figure 10. *Diagrammatic representation of tensiometer reaction to different amounts of irrigation*

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.

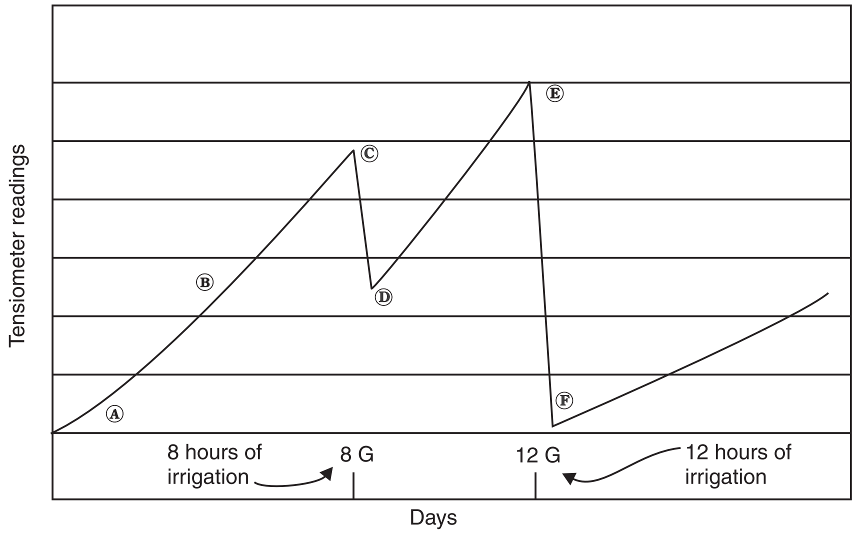


Figure 11. *A sample chart showing tensiometer readings plotted daily*

Maintaining tensiometers

Ensure that the water level is topped up regularly in the tensiometer. It is best to do this after 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 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 tensiometer tip 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 capacitance probe 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 they are recorded. Data from thelogger are down loaded to a computer every day or every few days and are available for viewing or printing within minutes. Figure 12 shows the main components of an Enviroscan probe.

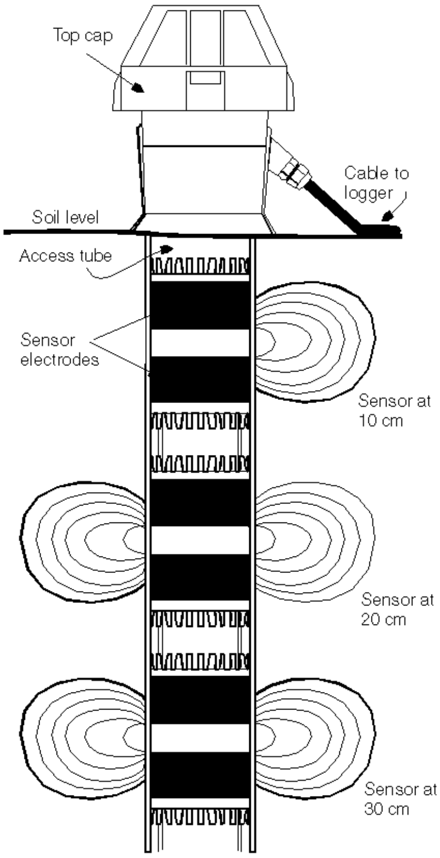


Figure 12. *Diagrammatic representation of an Enviroscan probe*

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 flower set, fruit filling and fruit quality in the crop.

For capsicums, 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.

Interpretation of the data requires skill and we recommend that consultants be used to set up the system and provide at least the initial advice. Figure 13 is a diagrammatic representation of the water use of a capsicum crop recorded by an Enviroscan. The high points occur after irrigation or rainfall.

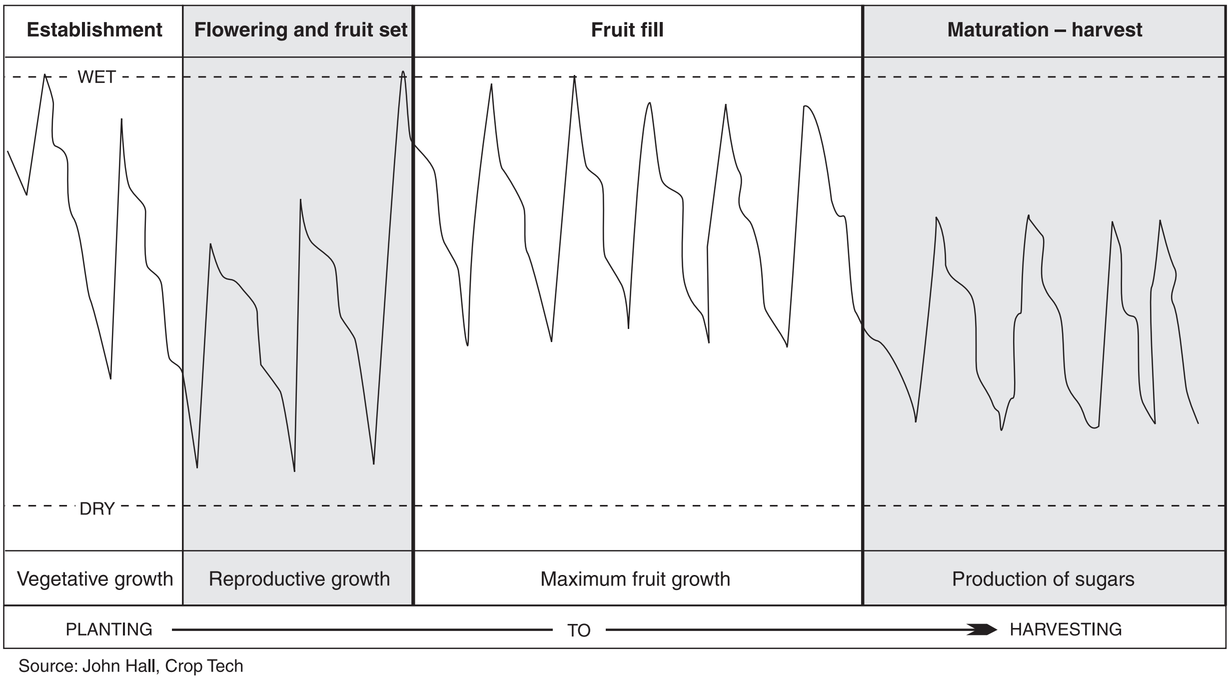


Figure 13. A diagrammatic representation of irrigation and water use of a capsicum crop as recorded by an Enviroscan

Maintenance of a trickle irrigation system

Before developing your irrigation system, have the 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 the water will kill the bacteria and prevent 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 water quality. You should talk to a reputable irrigation specialist before deciding on the type of filter you need.

The filters should be cleaned regularly, either manually or automatically. You should also flush out the pipes regularly, the dirtier the water the more often you need to do it. Fit flushing valves to the ends of trickle tubing so that the system is automatically flushed after 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 that you have used enough chlorine. The amount of chlorine required will depend on the quality of the 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 done continuously, using 1 mg/L residual chlorine; on a regular basis at about 10 mg/L; or as 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 irrigation.

The slug dose is only used if the trickle outlets are badly blocked or before used tape is to be reused. 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 main lines, 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 27 shows the amount of two chlorine products required to make two different concentrations of chlorine.

Table 27. *Chlorine product required for two concentrations of chlorine*

Concentration	12.5% chlorine product		65% chlorine product	
required	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 or put dye in the water to indicate when it has got through the system.

An integrated approach to pest and disease management in the field

Managing pests and diseases is probably the most difficult aspect of capsicum growing. 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 capsicum 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 pests with a range of control methods so that they do not cause economic damage. By pests, we mean insects, mites, fungi, bacteria, viruses and nematodes. 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 capsicum 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 methods 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 after capsicums, chillies, tomatoes, eggfruit or potatoes.

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

Land preparation. Good land preparation to assist plant establishment and reduce 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 unusual in capsicums, but 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 using trickle, overhead or furrow irrigation. All of these methods can have an influence on pest and disease problems. Remember that:

- overhead irrigation can wash sprays off the plant;
- mites can cause serious losses in crops grown under cover.

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 eggfruit caterpillar are usually worse in warm weather;
- mites prefer warm, dry conditions.

Selecting the right variety

more info
Variety descriptions
This section
pages 21 to 36

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

Monitoring (bug checking)

Monitoring capsicums for pests and diseases is the first step in the crop protection cycle. Without monitoring you have no evidence of what pest management strategies need to be carried out or how well your current pest management strategies are working.

more info
Horticultural consultants
Section 6 page 14

We recommend you use a competent pest consultant to do the monitoring. 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

1. A monitoring log book. A sample page that you can photocopy is on page 66 of this section.
2. A 10 power hand lens. Most optometrists stock these.
3. Plastic freezer bags to keep samples of pests unknown to you for identification.

It is not necessary to identify all the problems you find, but the more you can identify the better. Section 5, the *Problem solver,* will help you identify the more common problems of capsicums.

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 on the plant for each particular pest or disease. See 'Pest and disease monitoring' below for details.
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 monitoring log or a diary.
7. Simple tables and graphs of data help define patterns and maps help identify local problems and pest movement.

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 it identified. 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 on your farm.

Pest and disease monitoring

This procedure is one of several that can be used for pest and disease monitoring, as indicated in Step 3 above of 'How to monitor a crop'.

1. 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.
2. Look for wilted or yellowing plants and examine these for symptoms of disease or physical damage. In summer *Sclerotium rolfsii*, *Pythium*, bacterial wilt and sudden wilt are common while *Sclerotinia* and *Botrytis* are winter problems.
3. Thoroughly examine at least 10 and preferably 20 average plants per block up to about 2 ha and increase this number for larger blocks. Select the plants at random as you walk through the block.
4. Check around layflat hoses, hydrants, filters or other objects where spray coverage may be poor to see if any pests are present. Check also around the block for possible sources of reinfestation. Carefully note and record the following information:
   - The number and maturity of Heliothis eggs on the top three growing shoots, five flowers and the most mature fruit. White eggs are newly laid, brown eggs will hatch out soon, and shiny black eggs have been parasitised. Remove mature flowers to check for thrips and small larvae on the developing fruit.
   - The presence of any diseases, for example bacterial leaf spot and tomato spotted wilt virus, on the top third of the mature bush or the whole plant on young crops.
   - The number of aphids, Rutherglen bugs, silverleaf whitefly or other sucking pests on the top third of the bush.
   - Note the presence of diseases on the bottom two thirds of the bush.
   - The number of leaves showing mite damage.
   - Note any other symptoms on the plant.
   - Weed types and stages of growth, and if they are harbouring insect pests or diseases.
   - The number of moths and fruit flies in pheromone traps.

Record all observations in the monitoring log (see sample on page 66).

Capsicum pest and disease monitoring log

Block: ______________________________ Date: ______________

Weather since last monitored: ______________________________

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

	Insects and mites								Disease							Comments
Code	#	#	P	P	P	P	#	#	P	P	D	P	D	D	P	
Sample	Heliothis (eggs)	Heliothis (larvae)	Eggfruit caterpillar	Thrips	Twospotted mite	Silverleaf whitefly	Aphids	Fruit fly	Bacterial spot	Powdery mildew	Sudden wilt	Grey mould	Sclerotinia rot	Base rot	Virus	
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																
13																
14																
15																
16																
17																
18																
19																
20																
Total																
Average																
Trapped																

A guide to thresholds from planting to early fruit set

Pest	No. of plants per block	Part of plant to check	Record	Action threshold level Low	Medium	High
Insects and mites				**Average number per plant**		
Heliothis	10 – 20	Whole plant	No. of eggs	0 – 0.2	0.3 – 0.5	0.5+
			No. of larvae	0 – 0.1	0.1 – 0.5	0.6+
Thrips		Flowers	Presence	------- No levels set -------		
Twospotted mites	10 – 20	Lower leaves	Presence	0	1 – 2	3+
Silverleaf whitefly	10 – 20	Leaves	Presence	------- No levels set -------		
Aphids	10 – 20	Whole plant	Nymphs + adults	0 – 0.1	1 – 5	5+
Diseases				**Number of plants affected**		
Bacterial spot	10 – 20	Whole plant	Presence & activity	<10%	10 – 30%	>50%
Powdery mildew	10 – 20	Whole plant	Presence & activity	In North Queensland apply sulphur in warm weather		
Sudden wilt	100 m of row	All plants	Plant deaths	0 – 1	2 – 4	4+
Grey mould (*Botrytis*)	100 m of row	Whole plant	Presence & activity	0	1 – 2	2+
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+

A guide to thresholds from fruit set to harvest

Pest	No. of plants per block	Part of plant to check	Record	Action threshold level Low	Medium	High
Insects and mites				**Average number per plant**		
Heliothis	10 – 20	3 terminals + 5 flowers + the most mature fruit	No. of eggs	0 – 0.2	0.3 – 0.5	0.5+
			No. of larvae	0 – 0.1	0.1 – 0.5	0.6+
Eggfruit caterpillar	10 – 20	Fruit	Presence	------- No levels set -------		
Thrips	10 – 20	Flowers	Presence	------- No levels set -------		
Twospotted mites	10 – 20	3 lower leaves + 1 middle leaf	Presence	0	1 – 2	3+
Silverleaf whitefly	10 – 20	Leaves	Presence	------- No levels set -------		
Aphids	10 – 20	3 lower leaves + 3 terminals	Nymphs + adults	0 – 0.1	1 – 5	5+
Fruit fly	10 – 20	Whole plant + traps	Larvae + adults	0	0 – 2	2+
Diseases				**Number of plants affected**		
Bacterial spot	10 – 20	Whole plant	Presence & activity	<10 %	10 – 30 %	>50 %
Powdery mildew	10 – 20	Whole plant	Presence & activity	In North Queensland: apply sulphur in warm weather		
Sudden wilt	100 m of row	All plants	Plant deaths	0 – 1	2 – 4	4+
Grey mould (*Botrytis*)	100 m of row	Whole plant	Presence & activity	0	1–2	2+
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+

Developed in association with 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 crop 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 blocks, not the whole crop;
- use sprays that will be least damaging to beneficials.

Monitoring and action thresholds help you make these decisions. An action threshold is the critical level at which a decision is made. Below this threshold you maintain as many cultural practices as possible to reduce the pest's impact on your crop; above this threshold you start specific control measures targeted at the pest. The thresholds are based on the average number of pests found per plant.

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

Thresholds for insect pests are generally based on 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.

The threshold you set will also depend on the activity of beneficial insects and the risks involved in not controlling the pest. For example beneficials may build up rapidly with aphid populations and be more effective than chemicals. If you are growing a potato virus Y (PVY) resistant variety, there is no risk of aphids spreading this virus. A much higher level of aphid infestation could then be tolerated, probably until honeydew and sooty mould on the fruit become a problem.

Bacterial spot can cause serious leaf drop and fruit damage in wet weather and only protectant sprays are available. In wet weather, or if wet weather is expected, use the low threshold level as a guide to spraying.

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.

Using threshold levels

Broad thresholds developed by experienced crop monitors are presented on page 67 as a guide only. No scientific research has established definite action threshold levels for capsicums. With experience you may be able to refine these thresholds for your situation. Use these levels as a guide to when specific action should be taken as follows:

Low threshold figure should be used when pest pressure is or is likely to be high, or the crop is at a sensitive stage to that pest.

High threshold figure should be used when pest pressure is or is likely to be low, or the crop can tolerate the pest.

Medium threshold figure should be used at other times.

Reviewing the variations recorded in pest levels is another guide to making the decision to act.

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.

more info
Variety descriptions
This section pages 21 to 36

Once you have decided what pests need to be targeted you are ready to decide what control actions to use. The *Problem solver handy guide* lists the registered pesticides for use in capsicums. 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 insect pests of capsicums, however, growers can not depend entirely on natural or released beneficials, particularly for Heliothis. Beneficials may be insect parasites or predators, or bacteria or viruses that infect the pest. Nature provides many beneficials (spiders and wasps) in our fields. Some beneficials (*Trichogramma*, lacewings and predatory mites) are reared commercially and can be released into the crop. Others are available as sprays, for example *Bacillus thuringiensis*.

more info
Beneficial suppliers
Section 6 page 8

While there is a cost to using beneficials, they remove the cost of chemical applications and avoid the risk of pests developing resistance to the chemical controls. However, because of the high level of chemical application that can be necessary in capsicum production, it is difficult to base your pest control on beneficial insects. If possible avoid using pesticides which may kill the beneficial insects. Suppliers of predators and parasites will also provide a list of chemicals that are less damaging to beneficials.

Beneficial insects and mites

Beneficial insects which help control pests may be either parasites or predators. Parasites include:

- *Trichogramma* wasps that lay their eggs in Heliothis eggs which are then killed by the wasp larvae;
- small wasps that lay eggs in aphids and then develop within the aphid, causing it to become a mummy.

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's)

Bacillus thuringiensis is a bacterial biological insecticide used to control Heliothis larvae (tomato grub) and potato moth in capsicums. Bt's are applied as a spray and produce a toxin that affects the gut of the larvae. Table 28 shows some of the advantages and disadvantages of *B. thuringiensis* based products.

Table 28. *Advantages and disadvantages of Bt's*

Advantages	Disadvantages
Only affects caterpillars, does not harm beneficials	May take some days before the larva is killed, though it will stop feeding well before that
Reduces the risk of resistance developing to other chemical controls	Short persistence, they 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 capsicums. Monitoring for insects and mites and controlling them is critical to your success as a capsicum grower. The main problems are Heliothis, eggfruit caterpillar, aphids, twospotted mites, fruit fly, silverleaf whitefly and thrips.

more info
Pictures of pests *Problem solver*, Section 5

Heliothis (tomato grub, corn earworm, budworm)

Heliothis grubs are the larvae of *Helicoverpa armigera* and *H. punctigera* and are the major insect pests of capsicums. Management of Heliothis will influence the management of many other pests. Heliothis will be present throughout the year, though the grubs are more prevalent in warmer months and less prevalent in cold areas in winter.

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

There is a very low market tolerance for Heliothis damage in capsicums 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. Eggs are laid in terminals, flowers and young fruit, and young larvae feed on the flowers or young fruit. Older larvae bore into fruit, which then breaks down.

Monitoring

Monitor crops frequently enough so you can make good treatment decisions. Check the top of the plant, flowers and fruit. Look for ‘water bag’ fruit resulting from grub damage. Crops should be checked more frequently in warm weather as Heliothis (and other insects) 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 include beneficial insects or sprays of *Bacillus thuringiensis* (Bt's), a bacterial biological insecticide.

Beneficial insects—Trichogramma *wasps*

Many parasites and predators attack Heliothis eggs and larvae, however, they normally do not provide sufficient control.

The egg parasite, *Trichogramma*, a wasp, occurs naturally and can destroy many eggs. Parasitised eggs become black and shiny. *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. *Trichogramma wasps* are susceptible to most chemical insecticides. Follow the supplier's instructions and treat the wasps carefully, as they are delicate insects.

Bacillus thuringiensis (Bt's)

Bacillus thuringiensis (Bt's) is reasonably effective against Heliothis, however, its use may result in some fruit damage as the larvae must feed to obtain a dose of Bt. Bt's 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 several are registered for this purpose. Some insecticides kill only larvae while others kill both eggs and larvae.

more info
Problem solver handy guide

H. armigera has developed resistance to a range of insecticides in several chemical groups. These insecticides may no longer be effective. The *Problem solver handy guide* lists chemicals registered to control Heliothis.

Good coverage is important. Most eggs are laid on the terminal leaves, flowers and young fruit, 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 than older larvae and do less damage.

Eggfruit caterpillar

Eggfruit caterpillar, *Sceliodes cordalis,* can be a major problem of capsicums and eggfruit, particularly in North Queensland. Eggs are laid on the fruit calyx and the newly emerged larvae bore into the fruit. External damage is difficult to see, however, fruit often break down from bacterial soft rot, which infects the fruit through the entry hole.

Fruit damage is most common, but stems may also be damaged. Larvae may also tunnel down the stems of young plants. The larvae feed inside the fruit, but damage may not be noticed during packing and result in postharvest breakdown. Mature larva are pink with a brown head, about 20 mm long and emerge from the fruit.

Eggfruit caterpillars are generally worse in late spring and early summer, particularly if a succession of susceptible crops is grown. Other hosts include eggfruit, tomatoes and thornapple weeds.

Control of eggfruit caterpillar

Maintain good farm hygiene, and destroy old crops, volunteer host plants and weeds, for example thornapples.

Monitor for caterpillar damage in fruit, holes or 'waterbags', and look for wilted tips where larvae have tunnelled into plants. Spray with an appropriate chemical from the *Problem solver handy guide*.

Aphids

Aphids can occur in sufficient numbers to cause direct damage to plants by sucking sap causing wilting and leaf puckering. Their excretions or honeydew cause problems because it is sticky and hard to remove and a black sooty mould grows on it, making fruit unattractive and unsaleable.

Aphids can also cause serious losses by spreading viruses, for example potato virus Y (PVY), in varieties that are not resistant to it. The most common aphid involved is the green peach aphid, *Myzus persicae*, which has a high level of resistance to many insecticides.

Monitoring

Monitor crops to ensure that aphids do not build up to levels that will cause economic damage. Look for aphids under the leaves and look also to see if beneficials are active.

Control of aphids

Effective management includes good farm hygiene, planting varieties resistant to virus, and beneficial insects. Silver coated plastic and oil sprays can be used to deter aphids from landing in the crop.

Hygiene

more info
Resistant varieties
This section
pages 21 – 36

Destroy old crops as soon as harvesting is completed and destroy weeds that are alternative hosts to aphids. Check seedlings to make sure you are not bringing infested plants onto your property.

Beneficials

Natural predators of aphids include ladybird (coccinellid) beetles and their larvae, and hover fly and lacewing larvae. Several species of parasitic wasps lay their eggs in aphids. A wasp larva develops within each aphid, which dries and becomes swollen, tan/brown and mummified. An adult wasp emerges from the aphid mummy.

Beneficials can be effective in controlling aphids, but often aphid numbers build up to high levels before the beneficials gain control. If you are growing a variety resistant to potato virus Y (PVY) virus, larger numbers of aphids can be tolerated, allowing beneficials to build up sufficiently to control aphids.

Insecticides

If necessary spray with an appropriate chemical from the *Problem solver handy guide* to control aphids. Green peach aphid has built up resistance to several insecticides. Aim for thorough coverage of the undersides of leaves.

Fruit fly

Queensland fruit fly, *Bactrocera tryoni*, can cause heavy losses during the warmer months, but are present all year in most parts of Queensland. They are often worse after wet weather. They lay eggs in mature green or red fruit and the maggots tunnel into the flesh. Damaged fruit often breaks down due to the entry of bacterial soft rots and soon becomes a smelly, rotten 'waterbag'. Fruit fly is a serious quarantine pest and restricts the movement of fruit into most Australian states and overseas countries.

Monitor for infested fruit and spray if necessary with an appropriate chemical from the *Problem solver handy guide*. Lures that trap male fruit flies can be used to indicate the presence or rapid build-up of Queensland fruit flies. A postharvest insecticide treatment is required for most Australian states and overseas countries.

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. Tomato russet mite is found on capsicums but rarely causes severe damage.

Spider mites (twospotted mites)

Spider mites, usually twospotted mite *Tetranychus urticae*, infest a wide range of plants. They cause a yellow stippling of the upper surface of the leaf and a fine webbing underneath. They can also cause white to pale yellow stippling on ripe 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

Predatory mites can be bought 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 Some natural predators—adults and larvae of the ladybird *Stethorus* spp., lacewing larvae and predatory thrips—may also be present.

more info
Predatory mite suppliers
Section 6 page 8

Miticides

Several chemical miticides are 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 underside of leaves is essential for the chemicals to be effective. The *Problem solver handy guide* lists chemicals registered to control mites.

Silverleaf whitefly

Silverleaf whitefly (SLW) is a recent introduction to Australia. The white-winged adults and scale-like nymphs suck sap from the plants, reducing plant vigour and yield. They excrete a sticky substance called honeydew. The honeydew and the black sooty mould that grows on it foul the leaves and fruit. SLW also transmit geminiviruses but little is known about them and the threat they pose to capsicums in Australia.

Monitoring

Monitor crops carefully to ensure that SLW populations do not build up to damaging levels. SLW are found on the underside of leaves, the adults near the top of the plants and the older nymphs on lower leaves. Accurate treatment thresholds have not yet been determined.

Control of SLW

An IPM approach, including farm hygiene, preservation of beneficial insects and the use of insecticides when necessary, is the best way to manage SLW.

Hygiene

Ensure that seedlings brought onto the farm are free of SLW. If possible plant new crops well away, and upwind, from older infested crops. Destroy old crops immediately after harvesting is completed.

Beneficials

Several species of tiny wasps parasitise SLW nymphs. Predators, including lacewing larvae and ladybirds (coccinellids), eat nymphs and adults, and adults are caught in spider webs. Remember many beneficial insects are very susceptible to insecticides.

Insecticides

more info
Calibrating a boom spray
This section page 87

If necessary spray with an appropriate chemical from the *Problem solver handy guide*. As SLW is a new pest to Australia, chemical registrations are still being obtained, so check if other insecticides are registered or have a permit for use. SLW is resistant to many insecticides. Some soft insecticide options (oils) may help reduce SLW numbers with minimal damage to beneficials. When spraying it is important to get good coverage of the underside of leaves and time sprays to target the more susceptible younger nymphs.

Thrips

Thrips are mainly a problem because they spread tomato spotted wilt virus (TSWV) which causes plant stunting and fruit damage. They feed in the flowers, on leaves and fruit, and on weeds.

Monitor by shaking flowers over a piece of white paper and looking for symptoms of TSWV on plants.

Destroy old crops and weeds in and around the block, and spray to control thrips with an appropriate chemical from the *Problem solver handy guide*.

Disease management in the field

A range of field diseases affects capsicums but good management practices can minimise their effects. A key point to remember is that other solanaceous crops (for example tomatoes, eggplant) and weeds (for example nightshade) can be host to some capsicum diseases. Weed control and careful selection of rotational crops is of prime importance.

more info

Photos of disease symptoms
Section 5 *Problem solver*

Soil-borne diseases

Outbreaks of soil-borne diseases can be expected in the same area year after year. The causal bacteria/fungi survive in soil for long periods and can be carried to new areas in contaminated soil on implements or stakes and with water wash. The first symptom is usually wilting due to damaged, inefficient root systems or a girdled stem. There are three diseases that can cause serious losses.

Sclerotium base rot caused by the fungus *Sclerotium rolfsii* generally affects young plants and causes a brown discolouration at ground level. Infection is more common in warm, wet weather. The white fungus spreads over the base of the near-dead plant and is followed by the appearance of small, round, brown fruiting bodies called sclerotes, which can survive in the soil for years.

Bacterial wilt caused by the bacterium *Ralstonia (Pseudomonas) solanacearum* does not usually show symptoms until around fruit set, but in warm weather it can affect plants at any growth stage. It is mainly a problem in warm weather and wilting is not as rapid as in tomatoes. Symptoms include wilting, root rotting and a dark discolouration under the bark. It remains in the soil for many years.

Sudden wilt is caused by fungi, including *Pythium* and *Fusarium* species, and symptoms are generally not seen until about fruit set. Plants affected by sudden wilt generally have more extensive root rotting than bacterial wilt, and an internal red-brown discolouration in the woody tissue at the base of the stem.

Sudden wilt outbreaks can be very severe in some years. Low oxygen levels in the soil caused by excessive irrigation or rain, or high soil temperatures caused by using black plastic in hot weather, provide ideal conditions for the fungi involved in the disease. The plant root systems developed under these conditions are small and unable to provide sufficient water and nutrients to sustain the plant as it attempts to fill out its load of fruit.

Planting into beds that had a previous crop in them may increase the risk of sudden wilt as the causal fungi may have built up in the previous crop.

Management of soil-borne diseases

Maintain soil structure by incorporating green manure crops, but ensure they are decomposed before planting. Heavily compacted soils with poor structure, slow drainage and low aeration are prone to soil-borne disease problems. Soil preparation for plastic mulched beds often provides these conditions. On heavy soils prone to waterlogging, make hills higher to increase soil depth and drainage.

Use an irrigation scheduling device such as tensiometers or an Enviroscan to ensure that plants are neither over watered causing waterlogging and low oxygen levels, nor stressed through under watering. Ensuring that plants are not over watered when they are young will encourage them to develop bigger root systems as they search for water, however plants should not be stressed.

Use white or reflective plastic mulch instead of black during hot weather.

Leggy, overgrown, root bound seedlings are often associated with sudden wilt outbreaks. Deep planting of such seedlings puts the root system into soil that is often poorly aerated and predisposes plants to disease.

Other solanaceous crops, for example tomatoes, are also affected by the same soil-borne diseases and should not be used in rotation with capsicums.

If soil-borne diseases regularly occur, a fumigant, for example metham sodium, should be used as part of an integrated management program. Note that fumigants will not control bacterial wilt.

Root-knot nematodes

Nematodes are not normally a serious pest of capsicums. 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. These 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 tell whether you should be using a nematicide. Recent research has shown organic mulches (sawdust, manure, sugar cane 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** crop. Serious damage is unlikely unless nematode levels are high.

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

This is one 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 provide an indication of the degree of root-knot nematode infestation.

more info

Testing laboratories
Section 6 page 8

Some laboratories will test soil and root samples for nematodes.

Foliar diseases

Fungal and bacterial

The severity of leaf disease will vary markedly with weather conditions.

Bacterial spot caused by the bacterium *Xanthomonas campestris* pv. *vesicatoria* is the most common disease of capsicums in Queensland. It is usually more serious in wetter areas (for example Bundaberg and south Queensland) than in the dry tropical areas of Bowen and the Burdekin, where it is more a problem of early crops. Symptoms include irregular dark leaf spots and dead tissue around leaf margins. Moderate levels of leaf spot can cause severe leaf fall. Severity increases during periods of showery, windy weather or heavy dews. Bacterial spot can be seed-borne.

There are five known races of bacterial spot, and a survey in late 1992 showed that Races 1, 3, 4 and 5 occur in Queensland. Plant breeders have produced varieties resistant to bacterial spot Races 1, 2 and 3, but these varieties are not resistant to Races 4 and 5. However, plants with Race 1, 2, and 3 resistance do not appear to suffer as severely from leaf and fruit drop or fruit infection when they are affected by bacterial spot.

Powdery mildew caused by the fungus *Leveillula taurica* appears on leaves as pale areas with flecking. It is more common in warm dry areas and can cause severe losses in the Dry Tropics; it occasionally occurs in other areas. Leaf fall can be a serious problem and result in sunburnt fruit.

Sclerotinia rot caused by the fungus *Sclerotinia sclerotiorum* usually occurs during cool showery weather and affects mature plants. It causes brown cankers on stems or branches, which result in wilting. A white fungus with sclerotes (hard black reproductive structures) develops during moist conditions.

Management of foliar diseases

Old crops and crop residues can provide inoculum for most foliar diseases. Ensure old crops are destroyed and use clean seedlings at the correct stage of development to establish the new planting. Good farm hygiene, including destruction of old crops immediately after harvest and control of solanaceous weeds in a wide margin around the crop, is sound practice.

Bacterial spot can also be seed borne. Hot water treat seed if it has not previously been treated.

Some varieties have resistance to one or more strains of bacterial spot. At present, none have resistance to all known strains. Do not rely solely on plant resistance to give control of this disease. Copper-based chemical sprays should be used in conjunction with plant resistance.

Sulphur sprays are applied regularly in the Dry Tropics to control powdery mildew but specific control measures are not generally required in south Queensland. Increasing nitrogen levels may help if powdery mildew is a problem.

Apply a fungicide to control sclerotinia rot at flowering if weather conditions are favourable for the disease. Use appropriate chemicals from the *Problem solver handy guide*.

Diseases caused by viruses

The most common virus diseases of capsicums are mosaic caused by potato virus Y (PVY), capsicum mosaic caused by pepper mild mottle virus and spotted wilt caused by tomato spotted wilt virus (TSWV). They cause leaf distortion and mottling, particularly in the youngest foliage. Spotted wilt often causes light coloured, ring patterns on leaves. Fruit can also be affected. Virus infected plants often produce fewer fruit or distorted fruit.

Virus diseases are spread with plant sap. Aphids spread mosaic as they feed. Capsicum mosaic has no insect vector but is easily spread by leaf contact. Thrips spread spotted wilt. The viruses also occur in other solanaceous crops and weeds.

Aphids or thrips will transfer mosaic or spotted wilt from infected plants and weeds, while capsicum mosaic can be seed-borne.

Management of virus diseases

Good farm hygiene, including destruction of old crops immediately after harvest and control of solanaceous weeds and vectors in a wide margin around the crop, is sound practice. Spray to control aphids and thrips with appropriate chemicals from the *Problem solver handy guide*.

Fruit problems

Small dark spots on fruit are usually due to bacterial spot. Bacterial canker, a minor disease in this crop, causes small, raised, 'eye spots' on fruit. Anthracnose appears on ripe fruit as large, dark, sunken lesions, which often develop pink spore masses in humid weather. Grey mould (furry grey spots) is not usually a problem in field crops but can be severe in plant houses.

Yolo spot (also known as pitting, green spotting and stip) is a genetic disorder in some capsicum lines and shows as dark spots below the skin. Another non-pathological disorder is blossom-end rot, which occurs as a thin, light brown area of tissue near the blossom-end and on the side of fruit. This dead tissue may be invaded by a dark fungus (*Alternaria*). The cause is related to temporary water stress during periods of high water demand in hot weather. More frequent irrigation will reduce its severity and calcium sprays may help. Sunburn can also cause heavy losses if plants have been broken or lost many leaves.

The virus diseases cause abortion of young fruit, distorted growth or brown surface markings on fruit.

Fruit damage, for example by grubs or fruit fly, will allow infection by bacterial soft rot organisms and the fruit will become a brown, smelly 'water bag'. After packing, any fruit blemishes, whether caused by fungi, bacteria, insects or weather damage, can lead to further deterioration in storage due to infection by secondary soft rot bacteria.

Management of fruit problems

Many fruit diseases are part of the disease syndrome of foliage diseases and are alleviated by improved field management practices.

Bacterial soft rots can rapidly decompose fruit in the field or postharvest. They enter through wounds and are particularly troublesome during warm, moist weather. Crops affected by bacterial spot or insects are vulnerable. Wet weather harvesting also increases the risk. A postharvest spray or dip using a registered surface sterilant will remove bacteria from the surface of fruit. This should be done as soon as possible after harvest followed by rapid drying and cool storage. The primary cause of postharvest fruit problems, however, relates back to the condition of fruit in the field.

Disease control program checklist

The following is a checklist of disease management strategies aimed at reducing yield losses and profit in capsicum production.

Pre-planting

- ❍ All old crops on farm turned in.
- ❍ Nematode assay required.
- ❍ All crop residues rotted down in proposed field
- ❍ Pre-planting fumigation if previous history indicates fumigation may be necessary.
- ❍ Virus weed hosts destroyed.
- ❍ Spray gear checked (new nozzles) and calibrated.
- ❍ The variety selected has resistance to diseases present, for example bacterial spot and Yolo spot.
- ❍ The seed has been hot water treated.

Establishment

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

Early growth

- ❍ Be prepared to start a 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 and reduce spray interval in wet conditions.
- ❍ Check for first signs of *Botrytis* and *Sclerotinia*.
- ❍ Maintain steady crop growth without heavy top development.
- ❍ Monitor for insect vectors of virus diseases.

Harvesting

- ❍ Maintain foliar disease control program, paying attention to the chemical withholding period.
- ❍ Monitor for *Botrytis* in field and 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.

Seed treatment

To control seed-borne bacterial canker and bacterial spot you need to hot water treat seed at 50°C for 30 minutes. Do not treat seed if the seed supplier has already treated it. Seed-borne tomato mosaic virus (TMV) can be controlled by trisodium phosphate treatment.

Hot water treatment

Commercial laboratories will treat seed for you or you can do it yourself. The equipment needed to treat small quantities of seed (up to 100 g) more info

Where to buy hot water baths
Section 6 page 10

includes an accurate thermometer (0° to 60°C, calibrated in half degrees), electric frypan, large saucepan, fine mesh kitchen sieve, spoon, clock and absorbent paper tray. Precision hot water treatment equipment is commercially available.

To treat seed at 50°C, practise this method without seed until you are able to maintain a constant water temperature during seed treatment.

1. Warm the electric frypan and add 3 to 4 cm of water slightly above 50°C from a hot water system or electric jug. 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 50°C. When reading the thermometer, have the tip immersed to half the depth of the water.
2. Heat the water to 50.5°C to allow for the temperature to drop 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 (household detergent) to the water. Keep the seed in motion by gently stirring. Read the temperature and heat when necessary by turning the thermostat switch until the red light comes on, heating for five to 10 seconds, and then turning the thermostat switch until the red light goes off. Repeat the procedure every one to two minutes or when the temperature drops below 50°C. If the temperature rises quickly and approaches 51°C, lift the saucepan and rest it on the frypan edge, or add cold water until the temperature drops to 50°C. Maintain the water temperature at 50°C in this way until the recommended seed treatment time has elapsed.
3. When the hot water treatment is complete, pour the contents of the saucepan through the sieve and spread the seed on absorbent paper, away from direct sunlight, until it is dry.

Points to remember

1. 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.
2. 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

Tomato mosaic virus can be seed-borne and can be eliminated by soaking the seed in trisodium phosphate (TSP):

1. Soak the seed in a 10% solution of TSP for one hour, after cooling from the hot water treatment. The seed should be thoroughly wet.
2. After treatment, wash thoroughly in running water.

Postharvest pest and disease management

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

Cooling

Pest and disease problems develop much slower 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.

***Table 29.** Conditions and maximum storage life for capsicums*

Temperature	Relative humidity	Maximum storage life
7 – 13°C	90 – 95%	2 – 3 weeks

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

Seek specialist advice before buying a cold room as there are several important design features you need to consider.

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.

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. 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 the chlorine wash becomes less effective while below 6.5 pH the chlorine breaks down rapidly. 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, (see below for more information on using chlorine). Regularly check the level of chlorine in the water with, for example, a swimming pool test kit, and add more chlorine as it dissipates. Redox meters can also be used to check chlorine levels. If the water becomes dirty replace it to reduce fruit infection and staining. Dirty water also causes very rapid breakdown of chlorine.

These chemical treatments are applied to control fruit breakdown throughout subsequent handling and marketing. This may be fungal breakdown (anthracnose, grey mould, and Rhizopus rot) or bacterial soft rot. The *Problem solver handy guide* lists the appropriate postharvest treatments.

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 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. Add a wetting agent to ensure thorough wetting of the fruit.

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) and bromochlorodimethylhydantoin (Nylate) are alternatives to sodium hypochlorite.

Fruit fly treatment

Fruit fly infestation can also cause serious losses. The postharvest treatment is applied as a dip or a flood spray for chillies, however dipping is not permitted for capsicums. Fruit fly disinfestation must be the last treatment applied. Your local plant health inspector has up-to-date information on how to set up your equipment to meet the disinfestation requirements of other states. Postharvest treatment is only required for some markets, contact your nearest plant health inspector.

more info
Plant health inspectors
Section 6 page 17

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 after fruit is treated it be packed into cartons with gauze screening to prevent reinfestation.

Shed hygiene

Clean shed equipment, cold rooms and picking equipment 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 is given here. For a mature crop sprayed with a boom spray about 500 L/ha is applied, however much lower rates are applied if misters or Micronair equipment are used.

These calibration methods are a guide to ensuring that the equipment is performing correctly. The equipment should initially be set up by someone who is experienced in setting spray equipment for capsicum crops. They will help you select the type of equipment you need (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.

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. More information is available in the DPI book *Pesticide application manual*.

Boom spray without droppers

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 one hectare, that is:

Volume per hectare = output X time to cover 1 ha

Step 1

Output = the total output of all nozzles

OR

Output = average output multiplied by the number of nozzles

For example: If your spray rig has 15 nozzles (three spraying over each of five rows), with an average output of 2.5 L per minute, then:

Output per minute = 15 X 2.5 = 37.5 L/minute

Step 2

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

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

For 10 row lands you spray five rows at a time, so if they are 1.5 m apart, then:

Swath width (m) = 5 X 1.5 = 7.5 m

Step 3

To determine the time to cover 1 ha you need to know the swath width (from Step 2 above) 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 = 7.5 m (from Step 2); and time per 100 m (Step 3) = 60 seconds then:

$$\text{Time to spray 1 ha} = \frac{\text{10 000 X 60}}{\text{7.5 X 100}} = \text{800 seconds}$$

Divide this by 60 = 13.3 minutes per hectare

To work this out using a calculator: 10 000 x 60 = 600 000; divide by 7.5 = 80 000; divide by 100 = 800 seconds; divide by 60 = 13.33 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 = 37.5 L/minute X 13.33 minutes/ha

Volume /ha = 500 L/ha

Boom spray with droppers

The following example is for calibrating a spray rig 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 = average output multiplied by the number of nozzles

Example: If your spray rig has 18 nozzles (two spraying ach side of the plant and one over the row), with an average output of 1.5 L per minute, then:

Output per minute = 18 nozzles X 1.5 L /minute = 27 L/minute

Step 2

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

Example: If you have seven row lands you spray three full rows and half of the fourth (centre) row with each pass (Figure 14).

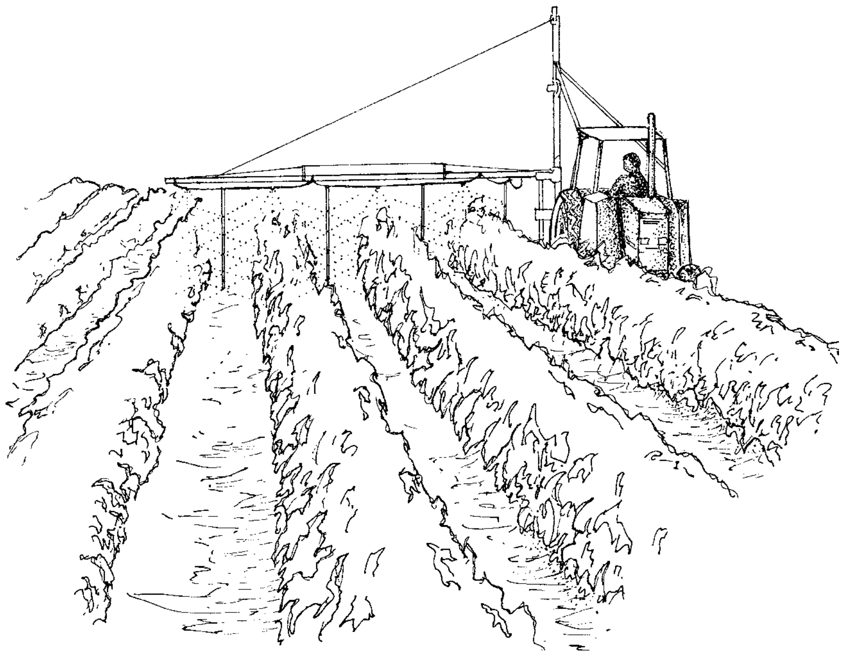


Figure 14. *A boom spray with droppers spraying a seven row land*

If the row spacing is 1.5 m and you are spraying 3.5 rows

Swath width = 1.5 m X 3.5 rows = 5.25 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.

Example: If swath width = 5.25 m (from Step 2) and time per 100 m (Step 3) = 60 seconds then:

$$\text{Time to spray 1 ha} = \frac{\text{10 000 sq. m X 60 seconds}}{\text{5.25 X 100}} = \text{1143 seconds}$$

Divide this by 60 = 19 minutes per hectare

To work this out using a calculator: 10 000 x 60 = 600 000; divide by 5.25 = 114 286; divide by 100 = 1143 seconds; divide by 60 = 19 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 = 27 L /minute X 19 minutes /ha

Volume /ha = 513 L/ha

Amount of chemical per tankful

To determine the amount of product to put into the tank, use these calculations.

Rate of product per hectare:

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

Example:

$$\frac{\text{3000 (L) X 2.2 (L or kg/ha)}}{\text{500 (L/ha)}} = \text{13.2 (L or kg)}$$

OR

Rate of product per 100 L:

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

Example:

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

Alternatives to methyl bromide

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

The immediate problem with methyl bromide

Gases such as chloroflurocarbons (CFC's) and halons are 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. The Commonwealth Government is progressively restricting import of methyl bromide over the period to 2005. This 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 crops can be planted 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.
- Because of its wide spectrum of activity, methyl bromide may also kill beneficial soil organisms including mycorrhiza. Although the short-term effects may be minimal, the long-term effects on soil fertility and structure 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 alternatives for methyl bromide is 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 progressing to assess alternatives.

Table 30. *Chemical alternatives to methyl bromide*

Chemical	Effective against			Current status
	Diseases	Nematodes	Weeds	
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, quintozene etc.	✔			Effective against some specific diseases but limited by cost, potential disease resistance and rapid degradation in soil.
Nematicides		✔		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

Chemical	Effective against: Diseases	Nematodes	Weeds	Current status
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 to methyl bromide 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 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. Also, you might 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 step as methyl bromide has been widely used as a general insurance against many 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.

Other production systems

Two alternative production systems that potential capsicum growers may consider are organic and hydroponic production. The following notes provide a basic outline of key issues for potential producers. A list of information sources and contacts is given in Section 6, Contacts and references.

Growing capsicums organically

Organic production of capsicums is very difficult because of the large number of pests and diseases that affect capsicums 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, as the reduced use of chemicals and other external inputs generally needs to be offset by a higher level of management skills and labour inputs.

more info
Grower associations
Contacts
Section 6 page 3

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.

more info
Where to get this book
Section 6 page 25

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

Some points to consider in organic production

Production timing is critical to but does not ensure success. Warm weather production, particularly when frequent rain can be expected, will increase the risk of diseases. Cool weather with heavy dews and fogs 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. 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, mites, eggfruit caterpillar and potato moth, all major problems during warm weather.

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

Organic growers need to be aware of the natural predators of aphids and other insects.

more info
Pest management in the field
This section page 71

Organic fertilisers (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. Capsicums 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 ones.

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 capsicums 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.

more info
Where to get this magazine
Section 6 page 27

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 obtain a copy and read it with an open mind.

Some points to consider in hydroponic production

Experienced producers and some newcomers have managed to produce hydroponic capsicums 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.

Positives

Protected growing systems. 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 (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 capsicum producer producing hydroponically *not* a hydroponic producer growing capsicums. Therefore, you will be competing on an existing market with both conventionally grown capsicums and other hydroponic capsicums; however the varieties grown hydroponically may sometimes be used to 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 capsicum 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 capsicum production is a labour intensive, time-consuming business.

Yields overestimated. 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.

Profits overestimated. The gross margin profit and return to capital estimated either by you or the promoter of a particular hydroponic scheme may have been overestimated. When working out prospective costs and returns, err on the side of caution or better still talk to someone who is already producing hydroponic capsicums 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.

a key issue
Gross margin
This section page 6

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 4

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.

Marketing and quality management

Marketing and quality management is a vital step in capsicum 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 capsicum production.

How do you sell your capsicums?

There are many options for marketing capsicums. These include selling:

- to a local merchant;
- to an agent or merchant at the major markets;
- direct to a retailer, for example the major supermarkets or smaller retailers;
- 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 whatever price they can get.

Know your market

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 capsicums

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

Customer demand

Consumers are becoming more demanding. They want capsicums to be consistently acceptable in quality, 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 and wholesalers) to be more demanding for quality and safety. For example, retail chains 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 that 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.

Food safety legislation

For the first time Australia is to have national arrangements for safe and hygienic production, storage, transportation and retailing of food. New national legislation and food safety standards have been designed to ensure that safety measures are applied at all stages of the food supply chain.

Food businesses from primary producers through to retailers will have to meet the requirements of these new standards. The standards are risk-based, meaning that businesses with higher food safety risks will have to take more precautions when developing their quality management systems than some other food businesses.

What makes up a quality management system?

A quality management system consists of the following parts, which 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. Many customers, for example Woolworths, are developing product specifications for their suppliers.

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 from individual cartons to the field. Computer-aided equipment that prints a code on each carton is also available.

Control of production processes

Control of production processes involves planning the production process and doing it correctly.

Monitoring products, processes and services. Checks to ensure that products meet specifications and 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. 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. The documents that are used to support a quality management system. They may include manuals, records, checklists, procedures, work instructions, job descriptions and training guides.

Reviewing and improving the system. 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 approved supplier programs to certified quality system standards 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 programs

An approved supplier program 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, growers 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 and safety records such as a spray diary;
- picking and packing to agreed quality standards;
- implementing a food safety plan.

more info

Where to get this guide
Section 6 page 23

The customer (or on independent company on behalf of the customer) conducts audits to check that the grower meets the approved supplier requirements. A guide titled *Developing an approved supplier program for fresh produce* is available from DPI.

Certified quality system standards incorporating HACCP

A certified quality system incorporating 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, the customer or an independent company on behalf of the customer does the auditing.

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 or the need to progress to ISO 9002.

SQF 2000

Developed by the Department of Agriculture in Western Australia for small businesses in the food industry, SQF 2000 is recognised in Australia, and is being promoted internationally. This standard consists of six elements incorporating aspects of ISO 9002.

SQF 2000 includes a management tool (HACCP), which is aimed at preventing food from being unsafe to eat. To achieve accreditation to SQF 2000, the HACCP plan must have been developed and verified by a skilled HACCP practitioner.

Woolworths Vendor Quality Management Standard

Woolworths Australia has developed a quality management standard for their suppliers aimed at food safety and quality requirements. 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 CA system takes over the inspection function of 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 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 growers must follow to meet interstate quarantine requirements. Queensland DPI audits each business at least once a year.

What is quality management going to cost?

There is no simple answer to this question.

Costs will depend on:

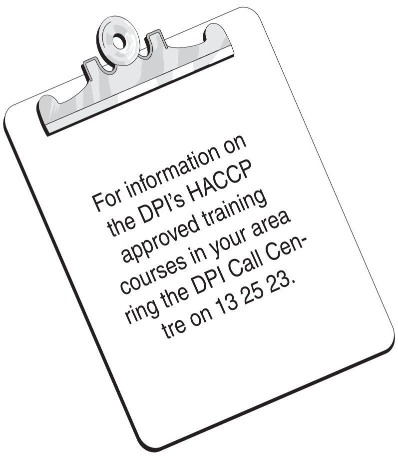
- size and complexity of the business;
- what level of quality management is wanted;
- how much knowledge the owner and staff have to develop and implement a system;
- whether outside help is needed.

Types of costs include:

- owner's time (this is the biggest cost);
- staff time involved in developing and implementing quality management;
- for large businesses, staff positions dedicated to quality management (monitoring, documentation);
- materials such as 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

The 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) runs 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:

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

Developing an approved supplier program for fresh produce—a guide for customers and suppliers, National Quality Management Working Group, (1999), Department of Primary Industries, Queensland and HRDC.

Available from:
Ms J. Barker
DPI Queensland
C/- Entomology Building
80 Meiers Road
INDOOROOPILLY QLD 4068
Ph: (07) 3896 9385; Fax: (07) 3896 9446