Strawberry information kit

Reprint – information current in 1997

REPRINT INFORMATION – PLEASE READ!

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 We advise readers to take particular note of the areas most likely to be out-of-date and so requiring further research:

- 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- Financial information—costs and returns listed in this publication are out of date.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 1997. The information is not current and the accuracy of the information cannot be guaranteed by the State of Queensland.

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

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Queensland Government

Key ISSUES

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

Understanding the strawberry plant

The strawberry is a complex plant and the way in which it grows and produces fruit is governed by a number of important factors. An understanding of these factors is vital if you are to get the best out of your strawberry crop. There are four things worth knowing about:

The growth options for a strawberry plant

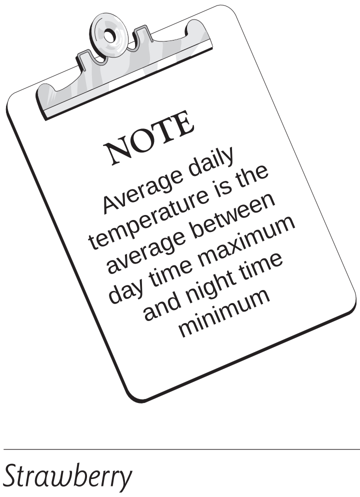
Strawberries are propagated by runners which are daughter plants produced on creeping stalks (stolons) from the parent plant. Runners consist of a shortened stem called a crown with roots at the base and leaves at the top. When a runner is planted, it will grow and produce new leaves and roots from its crown. The crown also forms buds and it is what happens to these buds that determines what the plant does next.

First of all, if it is too cold for the buds to grow (night temperatures regularly below 5°C), the plant becomes dormant. No leaf growth, flowering or fruit production occurs while the plants are dormant. This is what happens in the colder inland and highland areas of Queensland.

Where it is warm enough for the buds to grow, what happens next depends firstly on how the variety is genetically programmed to respond firstly to daylength, and secondly, the temperature.

On this basis, strawberry varieties can be broadly classified into three groups:

Short day varieties



These varieties get their name from the fact that they begin to flower when daylength shortens to below about 12 hours and average daily temperatures fall to below about 17°C. Approximately two weeks of these conditions are necessary for flowering to be triggered. When daylength lengthens to more than 12 hours and average daily temperatures rise above about 22°C, runners are produced instead of flowers. At temperatures between 17 and 22°C, plants grow leaves and new crowns. There is one important exception to this typical behaviour. If average daily temperatures remain below about 17°C during long days, flowering can still occur.

Maximum yields tend to be produced where days with temperatures of about 22 to 24°C are followed by nights with temperatures of about 12 to 15°C.

Short day varieties generally produce one main crop per year and flower, fruit and produce runners in that sequence. There is little overlap of fruit and runner cycles.

Most of the varieties currently grown are predominantly short day varieties. Some also exhibit characteristics of day neutral varieties.

Figure 1 provides a summary of the growth options for short day varieties.

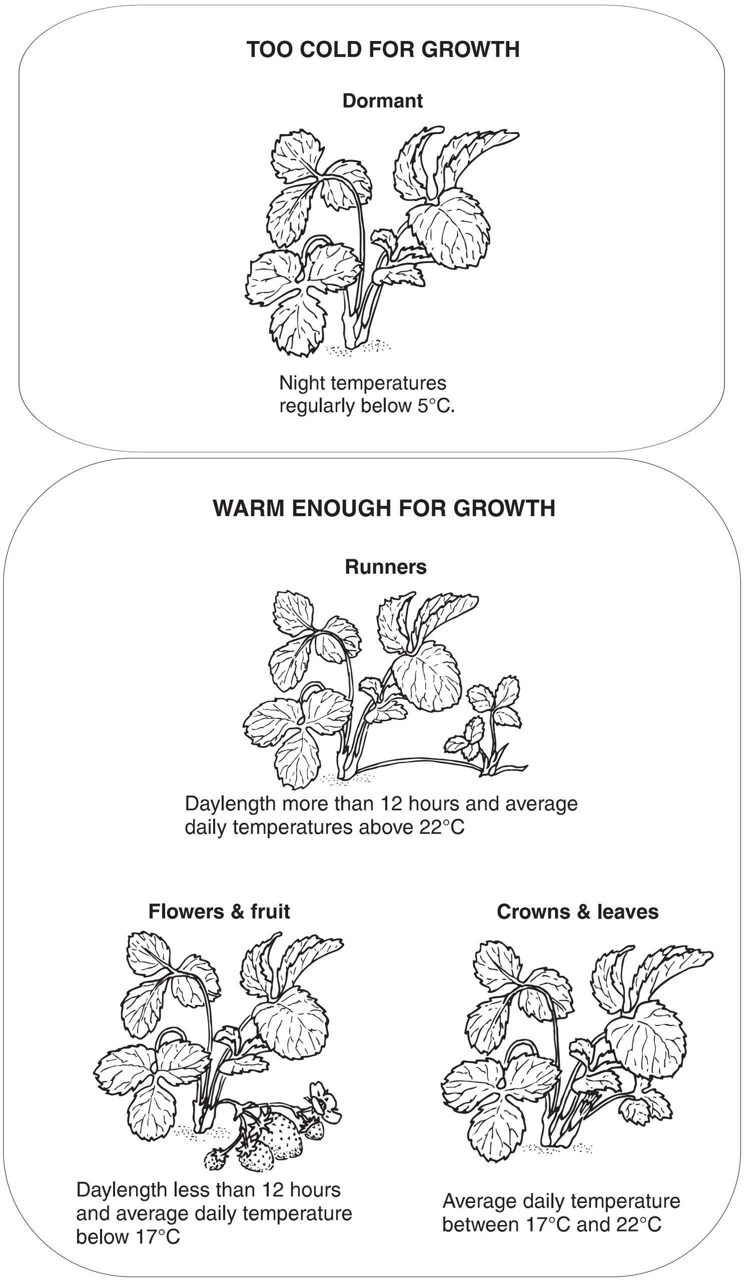


***Figure 1.** Growth options for buds for a short day variety*

From this, two important things can be seen:

- plants have to be growing to produce flowers
- conditions have to be cool enough for plants to produce flowers.

These two factors are the essence of coastal Queensland's strawberry industry which produces winter and early spring fruit out of season with other strawberry production areas of Australia. Winter and spring conditions here are warm enough to produce growth, cool enough to produce flowers, but not cold enough to make plants dormant. By comparison, in the colder inland and highland areas of Queensland such as the Granite Belt, plants will become dormant in most winters. Flowering is then confined to spring, summer and even autumn when conditions in these areas are generally cool enough to allow flowering.

One other important thing to appreciate from Figure 1 is that for plants to have any productive capacity, they need to produce a number of branch crowns—the more the better. Branch crowns should be seen as a pre-requisite for flowering and not in competition with it.

Day neutral varieties

In these varieties, flowering can occur at any daylength provided average daily temperatures remain within the range of about 10 to 25°C. Average daily temperatures below about 10°C cause the plants to become dormant while temperatures above about 25°C suppress flowering.

Day neutral varieties tend to crop continuously over a long period with several peaks of production. In contrast to short day varieties, they flower, fruit and produce runners simultaneously.

Of all the major varieties currently grown in Queensland, Selva is the only true day neutral.

Long day varieties (everbearers)

In these varieties, flowering is triggered by the long days of summer and temperature has relatively little effect. These types flower and fruit in a couple of cycles, generally in spring and autumn, but do not have any significant runner production cycle. Instead, they produce large multiple crowns during their vegetative state.

The only long day variety of note is Red Gauntlet, which is not grown commercially in Queensland.

Fresh and cold stored (frozen) runners

Growers have two types of runners available to them from commercial runner suppliers. As this often causes confusion, here is some explanation of the differences between the two types.

'Fresh' runners are the main type of planting material available and account for over 95% of Queensland's strawberry plantings. These are dug in March/April for immediate planting.

'Cold stored' or 'frozen' runners are mature runners left in the ground when the fresh runners are dug. Cold stored runners are dug in June or July and immediately put into cold store at -1 to -2°C for planting the following summer. To withstand the long period of frozen storage, they must be dormant when dug. This requires them to be grown in colder areas such as Victoria or Tasmania where plants become dormant in winter.

The reason why fresh runners predominate in Queensland is obvious when the performance of the two types of runners are compared. This is shown in Figure 2.

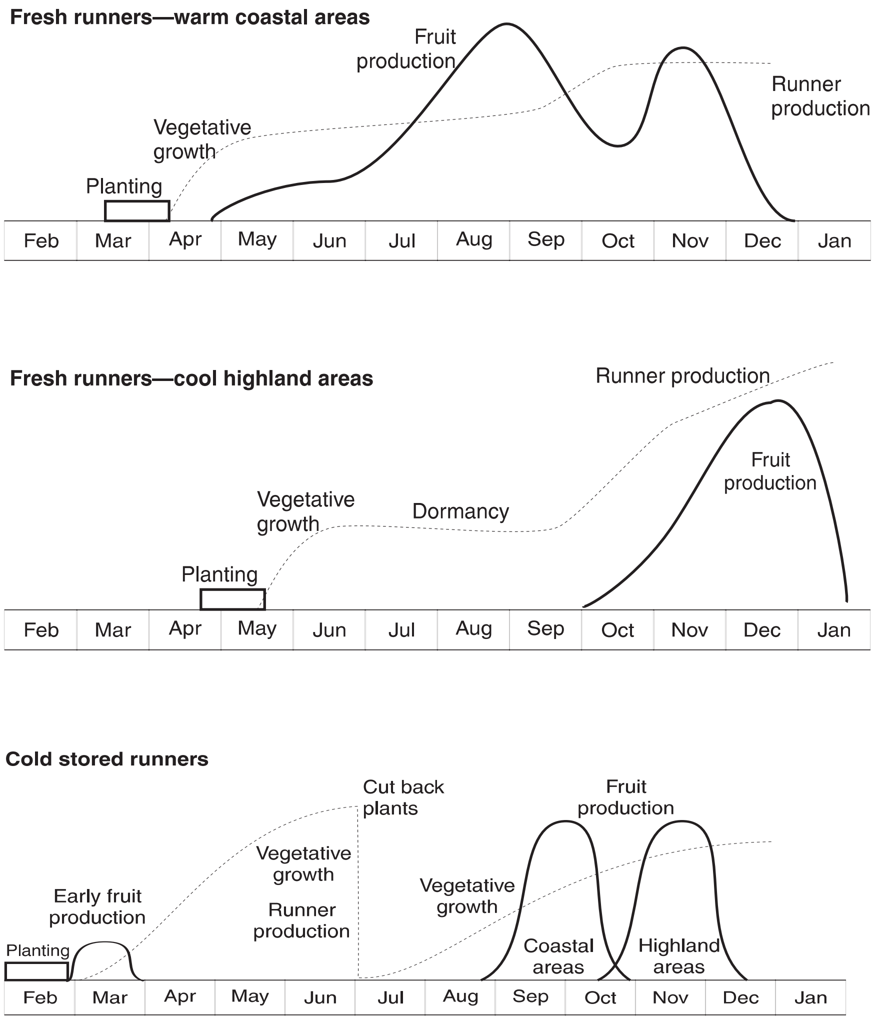


Figure 2. *Comparison of production between plants grown from cold stored and fresh runners (south east Queensland)*

You can see that it is the fresh runners that produce the 'out of season' winter and early spring fruit sought by most Queensland growers. The only advantage offered by cold stored runners is the high yielding compact crop produced in the mid to late spring. The disadvantage is the fact that plants have to be maintained over a long period for a relatively short period of production. Note that the small amount of fruit produced immediately after planting is generally of poor quality (small size, poor flavour, sometimes distorted, soft). Some is marketed but it is often removed and discarded to promote stronger leaf and crown growth.

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Managing cold stored plants
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As a result, cold stored runners offer little for coastal growers targeting winter and early spring fruit. However, they are a useful supplement to fresh runners for growers in the colder, inland and highland areas where climate limits production to late spring and summer.

Some cultivars perform poorly as cold stored runners and are only available in fresh runner form.

Fruit development

Another important thing to understand is how the fruit develops from the flower. The essential parts of the strawberry flower are shown in Figure 3.

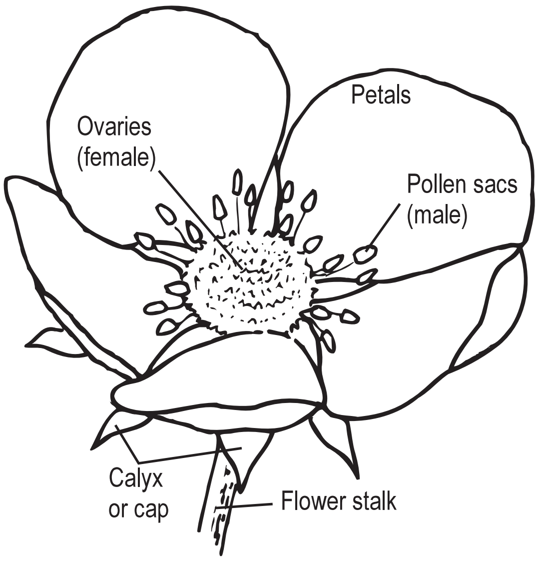

Figure 3. *A general view of the strawberry flower*

The swollen centre of the flower called the receptacle carries hundreds of female structures containing ovaries. Around the base of the receptacle above the petals is a ring of male structures carrying the pollen. When these structures ripen, the pollen sacs split to expose the pollen. Some is thrown forcibly towards the ovaries, the rest is left to be picked up by insects or wind and carried to the ovaries.

The important thing to appreciate is that each one of the hundreds of ovaries needs to be fertilised by pollen for a perfect fruit to result. This is because each fertilised ovary sends a hormone down to that small part of the receptacle beneath it to stimulate its growth and produce the fruit tissue as we know it. Any ovaries that remain unfertilised remain small and fail to stimulate the receptacle, resulting in distortion of the fruit. The fertilised ovaries are called achenes and are one-seeded fruitlets that become the 'seeds' on the surface of the fruit (Figure 4).

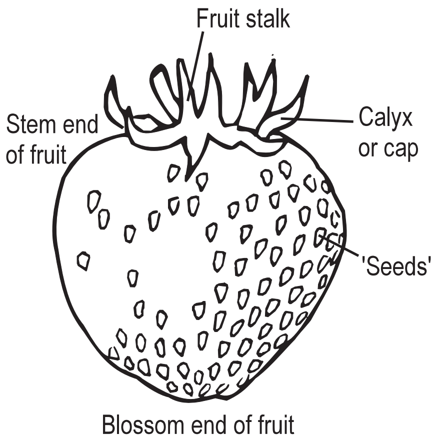

Figure 4. *The strawberry fruit*

The practical significance is that every effort must be made to maximise pollination of all ovaries on the receptacle. This means carefully managing pollinating insects such as honey bees and avoiding any damage to the fruit from sprays and insects.

Runner maturity

How runners work

Strawberry runners are very different from the essentially dormant seeds, corms, bulbs etc. used to propagate some other crops—runners are 'growing' plants.

Runners start their life attached by a lifeline (stolon) to a parent plant. Along the lifeline comes the nourishment required until the runner establishes its own roots and leaves to supplement the parent's supply. Along with all other green plants, the two important life processes that go on in the young runner are photosynthesis and respiration:

- Photosynthesis occurs in the green parts of the plant. It is the manufacture of carbohydrate (sugars and starch) from sunlight, carbon dioxide and water. These carbohydrates are sent down to the roots and crown for use and storage.
- Respiration occurs in all parts of the plant and can occur in light and dark. It is essentially the conversion of the stored carbohydrate into energy to keep the plant alive and to grow new tissues.

All of this changes when the runner is harvested. Three significant things occur:

- The runner loses its lifeline to its parent and so is on its own.
- Because the runner is removed from the light (into sheds, cool rooms, trucks), it stops producing carbohydrate from photosynthesis.
- Because respiration can occur under dark conditions, it continues (rate depends on storage conditions) and begins to use up the carbohydrate reserves to keep the plant alive. Runners are then in an increasing deficit position as far as carbohydrate is concerned.

The importance of all of this is that when the runner goes into the ground on your farm, it is the carbohydrate reserve that largely determines how well the plant establishes and starts growing. If it has good reserves, it can start growing immediately and grow new leaves to produce new carbohydrate reserves by photosynthesis. If reserves have been depleted, it struggles to just keep alive, and new leaf growth is slow or non-existent. Importantly, plants in this condition are more susceptible to disease and are more likely to die in hot weather.

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Handling runners
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The whole process of runner handling then is based on minimising respiration and the loss of carbohydrate from when the runner is harvested. This is mainly achieved by refrigeration of runners and planting as soon as possible after digging. It also involves minimising runner tissue damage (desiccation, broken leaves, crushed roots etc.), as the plant responds to this by increasing respiration to repair the damaged tissues. Careful handling is the key to success.

Note: do not confuse refrigeration of fresh runners (stored at no lower than 2°C) with frozen or cold stored runners. The latter are special runners grown into a semi-dormant state in winter to allow storage for long periods at below 0°C.

Recognise the importance of runner maturity

It is important to understand something about runner maturity. Runners that are more mature (dug later) are obviously larger and have greater carbohydrate reserves. This raises an important point that commonly leads to a misconception about runner quality between runners grown in Queensland and those grown in southern states. Queensland certified plants look different to those supplied from certified runner growers in Victoria and Tasmania. Because southern runners are dug and supplied later, they are more mature and have larger crowns. This does not mean that Queensland runners are of inferior quality. They are dug earlier to meet the need for early planting material and have just not developed to the same extent as southern runners. An important difference is that Queensland runners should be supplied with at least two mature leaves to assist runners establish. All leaves are trimmed from southern runners.

Having two mature leaves on earlier-dug Queensland runners is important as it means that these leaves can immediately photosynthesise and start to replenish carbohydrate reserves once the runner is planted. Research has confirmed that plants with leaves on had fewer losses, grew better and produced more early fruit.

The other important thing about runner maturity is that runners grown in coastal areas of Queensland are more immature and have lower carbohydrate reserves than runners grown in colder elevated areas such at Stanthorpe, where Queensland certified runners are currently grown. They thus require even more careful handling and a very rapid transition between digging and planting.

Economics of strawberry production

One way of assessing the profitability of strawberry production is by calculating what is known as a gross margin. A gross margin is the difference between the gross income and the variable or operating costs. The variable or operating costs include the growing, harvesting and marketing costs. The calculation does not consider fixed or overhead costs such as rates, interest, electricity, insurance and living costs, nor the cost of capital. Fixed or overhead costs and capital costs must be taken into account in calculating a whole farm budget.

Assumptions

The calculations are based on the following assumptions:

- the crop is grown under good management by a family unit
- all machinery operations include fuel, oil, repairs and maintenance only (FORM in the gross margin analysis)
- plant density is 45 000 plants per hectare
- an average yield of 2 punnets (500 g) of marketable fruit per plant for the season is achieved
- an average price across the season of $1.25 per punnet is achieved
- all fruit is picked and packed using casual labour with the grower supervising the operation
- the only other labour costed is casual labour to assist with planting. No allowance is made for owner operator labour.
- 50% of the crop is consigned to the Sydney wholesale market and 50% to the Brisbane wholesale market
- the farm is not subject to frosts so irrigation is confined to watering the plants only
- fruit is packed and marketed in 20 punnet cartons.

Gross margin for south east Queensland

Enterprise unit: 1 hectare

INCOME	Unit		Units/ha	$/unit	$/ha	$/plant	$/punnet
Sale of fruit	punnet		90 000	1.25	112 500	2.50	1.25

VARIABLE COSTS	Unit	Number	Units/ha	$/unit	$/ha	$/plant	$/punnet
Land preparation							
plough (FORM)	hr	1	10	12	120		
rotary hoe (FORM)	hr	1	5	12	60		
soil analysis	kit	1	1	80	80		
fertiliser - super	kg	1	375	0.2	75		
lime	kg	1	2500	0.1	250		
fertiliser application (FORM)	hr	1	2.5	12	30		
green manure seed (FORM)	kg	1	25	1.85	46		
sow green manure	hr	1	1.5	8	12		
harrow green manure (FORM)	hr	1	2.5	12	30		
urea for green manure	kg	1	100	0.4	40		
fertiliser application for green manure (FORM)	hr	1	1	10	10		
slash green manure (FORM)	hr	1	2.5	8	20		
rotary hoe green manure (FORM)	hr	1	5	12	60		
final soil working (FORM)	hr	1	5	12	60		
fumigation	contract	1	-	-	5500		
Total land preparation					**6393**	**0.14**	**0.07**
Planting							
plastic mulch (1.2m)	m	1	8500	0.13	1 105		
T-tape trickle tube	m	1	8500	0.14	1 200		
lay mulch, trickle and hill (FORM)	hr	1	20	12	240		
plants	each	1	45000	0.23	10 575		
casual labour for planting	hr	1	80	10	800		
sawdust between rows	m3	1	125	8	1 000		
sawdust application (FORM)	hr	1	8	8	64		
Total planting					**14 984**	**0.33**	**0.17**
Irrigation							
pumping costs	mL	1	6	26	156		
Total irrigation					**156**	**0.01**	**0.01**
Fertiliser							
dry tissue analysis	kit	1	1	80	80		
sap analysis	kit	5	1	50	250		
fertigation-potassium nitrate	kg	9	70	0.86	542		
magnesium sulphate	kg	4	8	0.65	21		
calcium nitrate	kg	6	50	0.83	249		
Total fertiliser					**1142**	**0.02**	**0.01**

VARIABLE COSTS	Unit	Number	Units/ha	$/unit	$/ha	$/plant	$/punnet
Weed control							
paraquat	L	1	4	8	32		
Total weed control					**32**	**0.00**	**0.00**
Pest & disease control							
pest scouting	contract	-	-	-	325		
predatory mites	pack	1	9	80	720		
insecticide - Delfin	kg	15	0.5	8	60		
insecticide - Lannate	L	6	1.5	12.80	115		
fungicide - Euparen	kg	30	2	6.00	360		
fungicide - Rovral	kg	10	2	34	680		
spray application (FORM)	hr	30	0.3	12	108		
Total pest & disease control					**2368**	**0.05**	**0.03**
Harvesting & marketing							
pick & pack	punnet	1	90 000	0.4	36 000		
punnets	punnet	1	90 000	0.04	3 600		
cartons	carton	1	4500	1.75	7875		
cellophane & labels	punnet	1	90 000	0.02	1800		
cooling	punnet	1	90 000	0.004	360		
freight - 50% to Brisbane	carton	1	2250	0.4	900		
freight - 50% to Sydney	carton	1	2250	0.8	1800		
commission and levies	11.7%				13 162		
Total harvesting & marketing					**65 497**	**1.46**	**0.73**
TOTAL COSTS					**90 572**	**2.01**	**1.01**
GROSS MARGIN (income minus costs)					**21 928**	**0.49**	**0.24**

Gross margin sensitivity analysis

Actual gross margin when price or yield changes

	Price per punnet		
Yield/plant	**$1.00**	**$1.25**	**$1.50**
1½ punnets	–$4 723	$10 178	$25 078
2 punnets	$2 060	$21 928	$41 795
2½ punnets	$8 844	$33 631	$58 513
3 punnets	$15 628	$45 429	$75 231

The next step

Remember that the gross margin does not take into account fixed costs (rates, depreciation, administration, registration etc.) or capital costs (land, machinery, buildings etc.). It also does not include the labour supplied by the grower or the grower's family. These need to be included in a whole enterprise budget. This is essential to determine whether you are providing yourself with a reasonable wage and a return on your investment.

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Strawberry farm management software
Section 6 Page 7

Selecting varieties

Success in commercial strawberry production depends more than anything else on the correct selection of varieties. It is not easy as there are many varieties to choose from and many differing opinions on which varieties are best. This section will help you make an informed decision on selecting varieties. Here are the important things you need to know:

What makes a good variety?

A good commercial variety should have the following characteristics:

- good yields (at least two to three punnets of marketable fruit per plant per season)
- early season fruit production (as much fruit as possible in the May to August period when prices are normally at their highest)
- good eating quality so that consumers will continue to buy strawberries. This means that the fruit must be well-flavoured, juicy, sweet and low in acidity. It should also have consistent eating quality throughout the production season.
- good fruit size to make it efficient to harvest and easy for consumers to prepare
- attractive fruit appearance (good even colour right up to the calyx, glossy skin, even shape, seeds not too prominent)
- be easy to harvest to minimise picking labour (well displayed on the bush, easily detached from the bush, good spread of fruit through the picking season)
- fruit with good shelf life (resistant to fruit rots, pest damage, rain cracking, bruising)
- relatively easy to grow (good resistance to pests and diseases, good plant vigour, produces good runners etc.)

As no one variety approaches all ideals, it is a matter of choosing those that have as many desirable characteristics as possible.

Characteristics of the 12 best varieties

The strawberry variety colour supplement on the next four pages details the main features of the 12 top varieties currently available in Australia.

Our rating of the best varieties

	Consumer acceptance	Yield	Earliness	Growing	Harvest/ postharvest	Overall
Kabarla	60	80	90	60	80	80
Redlands Joy	90	70	80	60	60	80
Chandler	90	60	40	60	80	70
Redlands Hope	50	70	80	60	60	60
Selva	50	70	80	50	80	60
Oso Grande *	70	60	50	60	70	60
Coogee	70	60	50	60	60	60
Mindarie	70	60	60	60	60	60
Pajaro	60	40	50	50	70	50
Parker	40	70	70	50	80	50
Redlands Star	90	40	50	60	40	50
Seascape	20	80	80	50	40	40

* = still very new

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Our variety recommendations
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Category definitions

- Consumer acceptance estimates whether consumers are going to like the fruit enough to buy more after the initial purchase. Criteria used include flavour, sweetness, juiciness, firmness, colour of flesh and skin, shape and fruit size.
- Yield estimates production from mid May to the end of October.
- Earliness looks at the time production starts and the volume of fruit produced before mid August when the total volume of fruit on the market increases substantially and prices start to fall.
- Growing looks at all the factors involved in growing the crop including pest and disease problems, ease of nutrition and irrigation management, display of fruit on the bush, plant size and vigour and susceptibility to rain damage, sunburn, uneven colouring and misshapen fruit.
- Harvest/postharvest covers performance of the fruit from picking until it reaches the consumer. It includes ease of harvest, ease of packing, susceptibility to handling damage, ease of transport and shelf life.

Each criterion is given a weighting which is used to calculate the overall rating of each variety for commercial production in Queensland. The following weightings are used:

Category	Weighting
Consumer acceptance	30%
Yield	15%
Earliness	15%
Growing	20%
Harvest/Postharvest	20%
Total	100%

Other things you should know

Growing your own runners

Please note that it is illegal to grow your own runners of any variety covered by Plant Breeder Rights legislation. All the above varieties are covered by this legislation except for Pajaro and Redlands Star. Pajaro and Redlands Star are covered by non-propagation agreements which make it illegal for growers to produce their own runners or runners for sale to others.

Certified runner schemes

We strongly recommend you only buy runners from runner growers who are part of a certified runner scheme. These schemes carry out regular inspections and virus testing to ensure you get a runner that has the lowest risk of virus and fungal infection.

Trial new varieties

New varieties are coming on to the market each season. Over the next two to three seasons, new varieties will be available from Spain, Israel, California, Italy, Florida as well as from the Queensland and Victorian breeding programs.

Always trial any new varieties in small numbers. Be careful not to accept the claims of the owners of the variety at face value, especially if trial results are from overseas. It is very rare for a variety to perform as well in Australia as it does overseas. DPI will continue to conduct new variety trials and publish results so growers can make an informed decision based on local performances.

Current use of varieties in Queensland

The use of varieties in the 1996 season is illustrated in Figure 1.

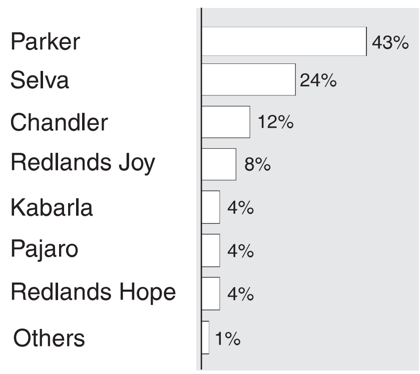

Figure 1. *Percentage of each variety grown in Queensland—1996 season*

Nutrition and sap testing

Everyone accepts that plant nutrition is an important part of achieving good yields and fruit quality. But there is evidence that yields and fruit quality may actually be declining through the excessive use of fertiliser in strawberries. This means that fertiliser use has to be much more carefully managed if optimum yields and fruit quality are to be obtained. Here are the things you need to know:

The traditional approach and its problems

The traditional approach to fertilising strawberries involves applying large amounts of manure or similar materials before planting, and then regularly applying manufactured fertilisers throughout the season. This is generally done without knowing whether the soil or the crop needs it or not. There is little or no testing of the soil or plants to determine the requirement for fertiliser.

This has led to excessively high levels of some nutrients, particularly nitrogen, phoshorus and potassium, in the soil and plants. This causes a number of problems:

- reduced yields from nutrient imbalance
- excessive plant vigour which delays the early onset of flowering
- fruit softening
- winter stunting of plants in cold wet soils
- albinism or poor colouring of fruit
- contamination of groundwater from excess nutrients being leached out of the root zone. This has been confirmed by recent research which shows that only 8 to 20% of nitrogen fertiliser applied to strawberries actually gets used by the plants. The rest (equivalent of up to 250 kg/ha of N) is lost, largely by leaching.

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

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

The new approach—monitoring with sap testing

The new approach relies on monitoring of soil nutrient levels before planting and then monitoring of plant nutrient levels throughout the growing season. It uses three different monitoring tools to cash in on the fact that some are more accurate and sensitive for particular times during the plant cycle. The three monitoring tools are:

- Pre-plant soil analysis. This ensures that soil nutrient levels are at their optimum before planting. It is particularly important for nitrogen which needs to be medium to high but not excessive at planting to ensure optimum leaf and root growth. It is also important to allow for the adjustment of insoluble nutrients such as phosphorus and calcium which are difficult to adjust once the beds are formed and the plastic is laid.
- Dried tissue analysis at flowering. This ensures that, at flowering, all nutrients in the plant are broadly in the right range. It is included because it is the most reliable test for calcium and the trace elements such as boron and zinc.
- Regular sap analysis from flowering. This ensures that plant nutrient levels are kept within their optimum ranges during the remainder of the season. It is important because it is much more sensitive for nitrogen than dried tissue analysis and can be done more quickly (on the spot if necessary). Its sensitivity can be gauged from research which shows that a relatively small difference in total nitrogen in dried tissue analysis can reflect a major difference in nitrate nitrogen in sap analysis. An example is shown in Table 1.

Table 1. *Comparison of the sensitivity between dried tissue analysis and sap analysis for nitrogen (Kabarla variety 1996)*

Dried tissue analysis	Sap analysis
3.13% total nitrogen	940 mg/L nitrate nitrogen
3.35% total nitrogen	3300 mg/L nitrate nitrogen

The detailed monitoring program

Pre-plant soil analysis (mid to late January)

Use a soil sampling kit purchased from your local farm supply store. Follow the instructions and send the sample away for analysis. Results will take about two weeks and will be supplied by the laboratory analysing your sample. The optimum nutrient levels to aim for are shown in Table 2. Discuss your results with your farm supply agent or consultant and work out how much fertiliser is needed to adjust all nutrients to the desired levels.

Table 2. Optimum soil nutrient levels

Nutrient	Optimum level
pH (1:5 water)	6 - 6.5
Nitrate nitrogen	50 mg/kg N
Phosphorus (bicarb - Colwell)	60 (sandy soils) to 90 mg/kg P (red soils)
Potassium (amm. acetate)	0.6 meq/100 g K
Calcium (amm. acetate)	5.0 meq/100 g Ca
Magnesium (amm. acetate)	2.0 meq/100 g Mg
Chloride	less than 300 mg/kg Cl
Electrical conductivity	less than 1 dS/m
Copper (DPTA)	1.0 mg/kg Cu
Zinc (DPTA)	2.0 mg/kg Zn
Manganese (DPTA)	4.0 mg/kg Mn
Iron (DPTA)	10 mg/kg Fe

Dried tissue analysis (at the start of flowering)

Use a tissue sampling kit from your local farm supply outlet and follow its sampling instructions. The correct leaves to sample are the youngest fully expanded leaves (Figure 1). Sample the whole leaf (three leaflets) plus the leaf stalk or petiole. Sample 80 leaves at random. Do not mix varieties - sample each variety as a different sample.

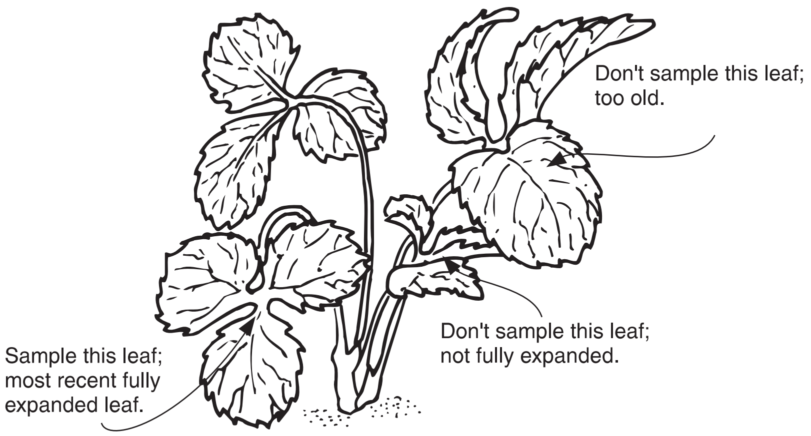

***Figure 1.** Correct leaf to sample for dried tissue and sap analysis*

Your results will be interpreted by the laboratory analysing your sample. The desired leaf nutrient levels for strawberries are shown in Table 3. Discuss your results with your farm supply agent or consultant and work out how much fertiliser is needed to adjust all nutrients to the desired levels.

Table 3. Optimum leaf nutrient levels (based on dry weight)

Nutrient	Desired Level
Nitrogen	2.7 – 3.3%
Nitrate nitrogen	less than 800 ppm
Phosphorus	0.3 – 0.5%
Potassium	1.6 – 2.5%
Calcium	0.9 – 1.5%
Magnesium	0.2 – 0.5%
Sulphur	0.1 – 0.2%
Copper	6 – 80 ppm
Zinc	25 – 50 ppm
Manganese	31 – 350 ppm
Iron	70 – 200 ppm
Chloride	0.1 – 0.4%
Sodium	less than 0.2%
Boron	30 – 50 ppm

Sap analysis (from the start of flowering)

It is best to use a nutrient monitoring consultant (where available) and get them to do the test for you. It is a little complex, involving the collection of leaf stalks of the youngest fully expanded leaves (Figure 1), extracting sap with a garlic press, mixing the sap extract with water and analysing the solution with reactive indicators. Where consultants are not available, consult one of the sap testing laboratories to arrange overnight courier transport of your sample to the laboratory. If you feel you have the skills to perform the analysis yourself, some details on how to do it are contained in the next section. Complete the sampling by mid-morning. Optimum sap levels established to date are shown in Tables 4 and 5.

more info
Sap testing consultants & laboratores
Section 6 Page 6

Table 4. Optimum sap nitrate levels

Variety	Sap nitrate level (mg/L)
Seascape	600 – 800
Redlands Joy	600 – 1000
Chandler, Redlands Hope	800 – 1200
Parker, Tioga, Mindarie, Coogee	1500 – 2000
Kabarla	2000 – 2500
Selva	2500 – 3500

Table 5. Optimum sap levels for other nutrients for all varieties

Nutrient	Desired sap level (mg/L)
Potassium	greater than 4000
Phosphorus	100 – 250
Calcium	300 (to end of June); greater than 600 (rest of season)
Magnesium	greater than 300

Where adjustment is required, discuss the options with your consultant or the sap testing laboratory.

After the initial sap analysis test at flowering, continue sap monitoring for the rest of the season. Monitor sap nitrate once per month (except for August—see below) with a full analysis (nitrate, phosphorus, potassium, calcium and magnesium) two or three times during the season.

Important notes on sap testing

- If soil nutrient levels were properly adjusted before planting, and no significant leaching has occurred, it is probably only nitrogen that will require adjustment from flowering onwards. Indeed, there appears to be no significant response to further applications of potassium and calcium at this point.
- A natural drop-off in sap nitrate levels occurs in mid August. This appears to be because the plants turn off fruit production between fruit flushes and instead produce new roots. As a result, sap testing can be suspended during this month. Also, the plant's ability to take up nutrients is limited so no nitrogen fertiliser should be applied at this time. This prevents a buildup of nitrogen fertiliser in the soil and reduces the potential for leaching of nutrients into the ground water.
- Try to have plant nitrate levels close to optimum going into August so that plants can commence fruiting again quickly after the turn-off period in August (Figure 2).
- Recommence sap testing in September and apply nitrogen fertiliser if levels do not quickly recover to within the optimum range. The mid September period represents a peak demand period for nutrients.
- As there are significant differences in the nitrogen requirements of different varieties, always sample each variety block separately.

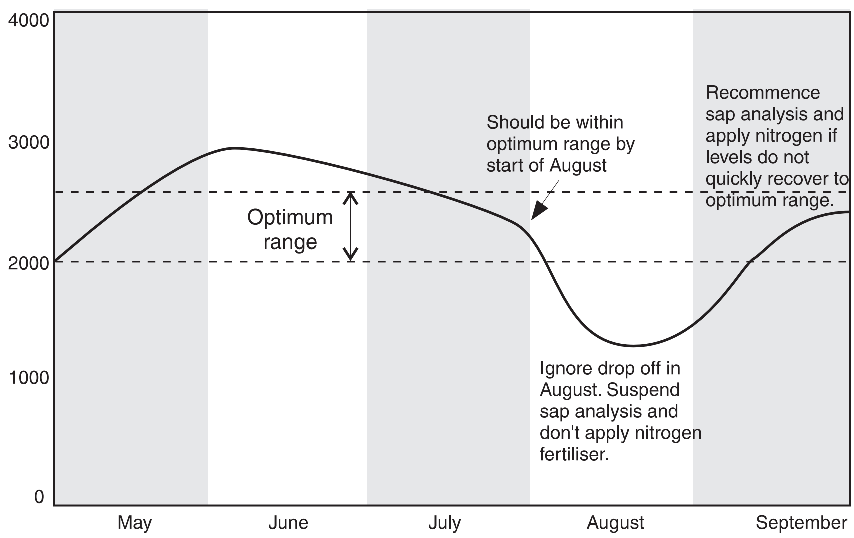

Figure 2. *Graph of seasonal nitrate nitrogen levels for Kabarla variety*

Do-it-yourself sap testing

Because the sap analysis procedures are somewhat complex, the use of sap testing consultants or a sap testing laboratory is recommended. Where these services are unavailable, the following guidelines may be useful.

Essential equipment required

- garlic press
- small plastic capped tube
- 1 mL plastic pipettes
- a number of 20 mL calibrated capped jars or tubes
- 500 mL wash bottle
- plastic measuring cylinder
- Merckoquant test strips for nitrate, phosphorus, potassium and calcium

Optional equipment

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

OR preferably

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

Procedure

1 Collect a random sample of 30 leaf petioles (leaf stalks) from different plants. Remember to sample by mid morning and to keep each variety as a separate sample.
2 Cut the petioles into small segments about 2 mm long.
3 Using the garlic press, squeeze sap into the plastic capped tube.
4 Mix the sap thoroughly.
5 Pipette 1 mL of the mixed sap into the 20 mL calibrated jar.

Nitrate and calcium tests

6 Dilute the sap to 20 mL with distilled water and mix thoroughly.
7 Briefly immerse each strip.
8 Read the concentration.
9 Multiply by 20 to get the concentration in the undiluted sap.

Potassium and phosphorus

10 Pipette 1 mL of the mixed sap from step 4 above into another 20 mL calibrated jar.
11 Using the measuring cylinder, add 4 mL of distilled water.
12 Mix thoroughly.
13 Briefly immerse each strip.
14 Read the concentration.
15 Multiply by 5 to get the concentration in the undiluted sap.

The potential of slow release fertilisers

In Queensland, most fertiliser applied to strawberries is of the immediate release type, for example urea. This is the most economical form to use but it may need to be applied regularly during the season as sap analysis indicates.

Research is currently being conducted on an alternative system using slow release fertilisers. These are widely used in California and recently in southern states. Slow release fertilisers are more expensive but have the advantage that they may need to be applied only once—at planting.

Results are promising so far, but it seems that if the weather for the first eight weeks or so after planting is very mild, the fertiliser may release quickly, making available a high level of nitrogen for plant uptake. This is of course undesirable as it encourages excessive plant vigour, delaying the onset of flowering. This early release is likely to be a particular problem in Queensland as mild conditions are often experienced in April and May after planting. Also, data so far suggests that extra nitrogen fertiliser may be required during the winter to hold the nitrogen levels in place.

Growers may wish to conduct small scale trials using slow release fertiliser while the research is proceeding. If you do, the best form to use is Agroblen Strawberry Mix. Careful application is required to avoid root burn. The best method is to place a band about 150 mm deep during bed forming. The band needs to be below and to the side of the plant (Figure 3). An alternative is to hand dibble the fertiliser into a hole about 100 mm deep positioned about 20 mm away from the runner (Figure 4). Apply after planting. About 15 to 20 g of fertiliser per plant is suggested.

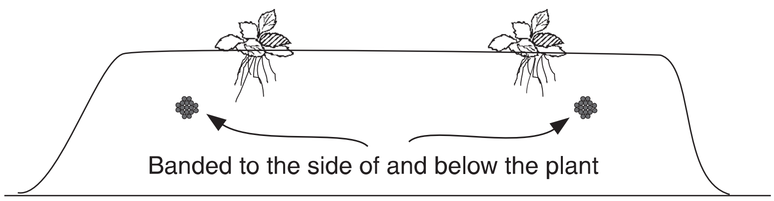

***Figure 3.** Position of band when using slow release fertiliser*

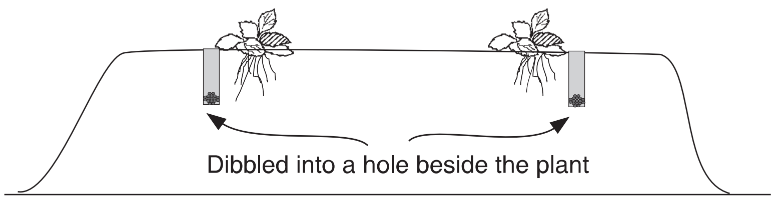

***Figure 4.** Position of dibble hole when using slow release fertiliser*

Irrigation and water monitoring

Although the plants may not show it, strawberries are very sensitive to water status. Yet surveys tend to confirm that most strawberry crops are either underwatered or overwatered. Careful management of irrigation is therefore a key factor in optimising yield and fruit quality. Here are the main things you need to know:

The importance of getting irrigation right

Too little water

Strawberry plants have relatively shallow, fibrous root systems, with most roots in the top 30 to 40 cm of the soil profile. This makes them highly susceptible to water stress, resulting in reduced yields and poor fruit size and quality. In extreme cases, fruit scalding may occur. These effects occur well before the plant shows any sign of wilting or obvious water stress.

The fact that strawberries are grown on plastic mulch provides an additional difficulty in that it is difficult to re-wet the soil under the plastic, once it has dried out. This is particularly so for overhead irrigation systems. Even drilling holes in the plastic to allow water through, makes little difference.

Too much water

To guard against the problem of underwatering, it is easy to go to the other extreme and apply too much. This reduces yield through reducing soil aeration, increases the incidence of root diseases and reduces fruit quality. Overwatering also leaches fertiliser out of the root zone. This not only wastes fertiliser but also poses a serious environmental hazard, polluting groundwater with excessive amounts of nutrients.

Irrigation must No. 1—a good irrigation system

The first essential requirement of efficient irrigation is a water supply and irrigation system capable of delivering the required amounts of water when needed.

A combination of overhead and trickle irrigation systems is recommended. Overhead sprinklers are required to help get the plants established and later on to protect plants against frost damage where necessary. Overhead sprinklers are also useful in providing a good environment for the establishment of predatory mites.

After plants are established, a trickle tube under the polythene mulch is used for the main crop watering and for the application of soluble fertilisers. Although trickle watering requires more careful management than overhead sprinkling, it has a number of important advantages for the main crop watering. It uses much less water, avoids washing off protective chemicals, reduces leaf and fruit diseases, provides more efficient wetting of the root zone and can be used to apply soluble fertilisers directly into the root zone of the plants. Use a trickle tube with outlets no more than 20 cm apart.

If you elect to use overhead sprinklers alone, use single knocker, impact sprinklers on short risers to allow spray machinery to pass overhead. If using the dual overhead/trickle system, the overhead sprinklers play a secondary role and cheaper components can be used to save costs. Where frost is not a problem, the overhead sprinklers can be replaced with misters for the purpose of establishing runners and providing the favourable environment for predatory mites.

Whatever system you use, it must be able to supply water to a depth of about 60 cm, as that is the normal depth that strawberry roots reach in the soil profile.

Irrigation must No. 2—a monitoring system

The second essential requirement of efficient irrigation is a system to tell you when and how much water your crop needs. This is known as a monitoring or scheduling system. The importance of monitoring is confirmed by research which shows that water use can be reduced by up to 40% 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 are available for monitoring soil moisture and scheduling irrigation. The most common are the soil based systems using neutron soil moisture probes, tensiometers, or newly developed soil capacitance systems such as the Enviroscan. The other technique sometimes used is a climate based system based on estimates of evapotranspiration. The soil based systems are preferred and recommended. A brief comparison of the main systems is shown in Table 1.

Because strawberries have the bulk of their roots in the top 30 to 40 cm of soil, any soil water monitoring device used for irrigation scheduling needs to concentrate on this part of the soil profile.

more info
Irrigation consultants
Section 6 Page 6

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

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

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

Tensiometers

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

HINT
The book, Water it right: irrigation using tensiometers is a valuable reference on this subject. Details of where you can get it are in Section 6 page 14.

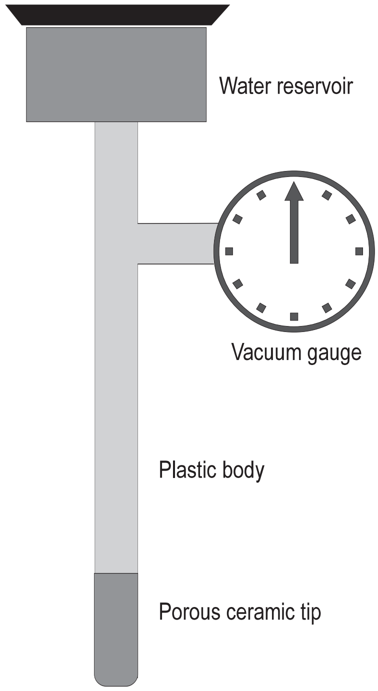

Figure 1. *Parts of a standard tensiometer*

Monitoring sites

Tensiometers are installed about one month after planting at monitoring sites throughout the crop. They are then left in place until the end of the season. Use at least one monitoring site for each variety or block of plants. At each site, install one and preferably two tensiometers—one 30 cm long tensiometer installed in the major root zone at a depth of about 15 to 20 cm, and one 60 to 90 cm long tensiometer below most of the roots at a depth of about 50 to 60 cm. Place tensiometers about 15 cm from the centres of plants and at least 15 cm from the trickle tube. Placement of the shallow tensiometer is shown in Figure 2.

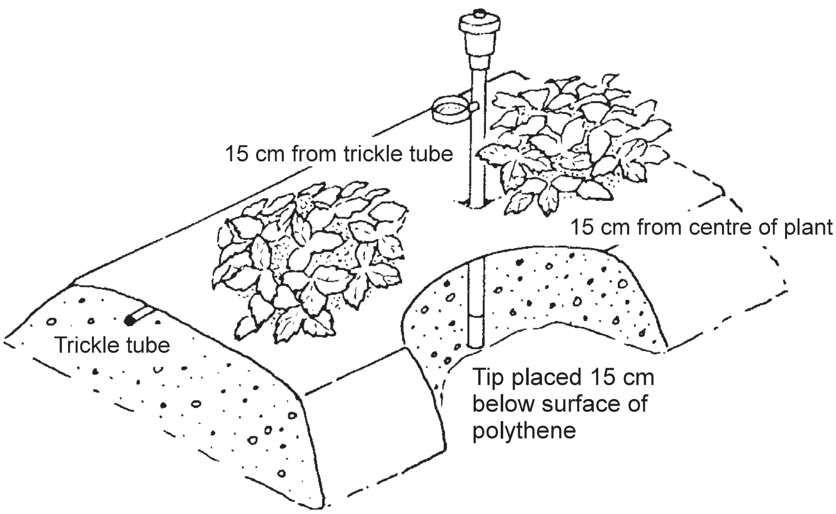

Figure 2. *Tensiometer placement in a strawberry bed*

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 simple be pushed into the soil to the 15 to 20 cm depth. Don't push too hard! The tips are strong, but can crack under excessive pressure. Only experience teaches how hard is too hard. At $30 per tip, this can turn out to be an expensive lesson. If you encounter a hard soil layer, either take the tensiometer out and try somewhere else, or use the deep tensiometer procedure.

To install the deep tensiometer, first make a hole to the required depth, keeping the excavated soil nearby in a pile. We have found a 50 mm auger the best tool. Place the tensiometer in the hole, over to one side. The next step is critical. Good contact between the ceramic tip and the surrounding soil is very important. Take the most crumbly, moist soil from the dirt pile and pack it around the tip at the base of the hole. A piece of 10 to 15 mm diameter dowel is useful for packing. Don't 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 after you have packed the first 5 cm above the tip. Friable topsoil from a few metres away can be used to create a slight mound around the tensiometer. This minimises water draining down beside the tensiometer leading to false readings. Covers made from silver/blue insulation foil placed over the tensiometers minimise temperature fluctuations and algal growth. The gauge can be left exposed for easy reading.

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

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

Reading

Read tensiometers early in the morning between 7.00 a.m. and 9.00 a.m., preferably the same time each reading. Read at least twice a week but preferably every day or second day. Lightly tap the gauge before reading.

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

Irrigating using tensiometers

If using just the one shallow tensiometer per site, use Table 2 as a guide to watering.

Table 2. *Readings to start and stop watering (one tensiometer)*

Watering system	Start watering	Stop watering
Overhead	10 – 12 centibars	0 – 5 centibars
Trickle	5 – 7 centibars	0 – 2 centibars

If using two tensiometers per site, use Table 3 as a guide to watering.

Table 3. *Readings to start and stop watering (two tensiometers)*

Watering system	Start watering	Stop watering
Overhead	10 – 12 centibars (shallow)	0 – 5 centibars (shallow) and 5 centibars (deep)
Trickle	5 – 7 centibars (shallow) and 2 centibars (deep)	0 – 2 centibars (shallow)

Note: these figures are a guide only and are based on well drained soil conditions. Growers need to adjust their irrigation programs to their particular set of conditions.

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 greater 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; and if there are no obvious tip cracks, re-install the tensiometer. If the problem persists, replace the tip.

No change in readings over several days

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

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

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

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

The neutron probe

This is a very sophisticated device consisting of a probe containing a neutron source and a detector. A number of access holes are set up in the crop and the probe is brought to these sites at regular intervals during the season. When the probe is lowered into the access holes, neutrons from a radioactive source are emitted into the soil profile.

When these fast neutrons collide with hydrogen atoms in water, they slow down dramatically and are deflected back to the detector which responds to slow neutrons only. If the soil is dry, the neutrons do not slow down and are therefore not detected. Readings are taken at various depths to provide an overall view of soil moisture within the profile.

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

The Enviroscan capacitance probe

This is a continuous moisture monitoring device based on capacitance sensors. The sensors are mounted on probes which have slots every 10 cm to accommodate the snap-in sensors. These probes are then placed within vertical PVC access tubes installed in the soil after the crop is established. The probes and tubes are left in place until the end of the season. Sensors are positioned on the probes to provide readings at specific depths.

Measurements from the sensors are relayed at regular intervals via a cable to a data logger where it is recorded. The data from the logger is downloaded to a computer every day or every few days to show water use and to provide recommendations for watering. Figure 3 shows the main components.

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

The current cost of a logger, solar panel, 100 m of cable, two 1 m probes, 10 sensors and software is about $8000. The equipment can also be hired from some consultants.

more info
Enviroscan consultants
Section 6 Page 6

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

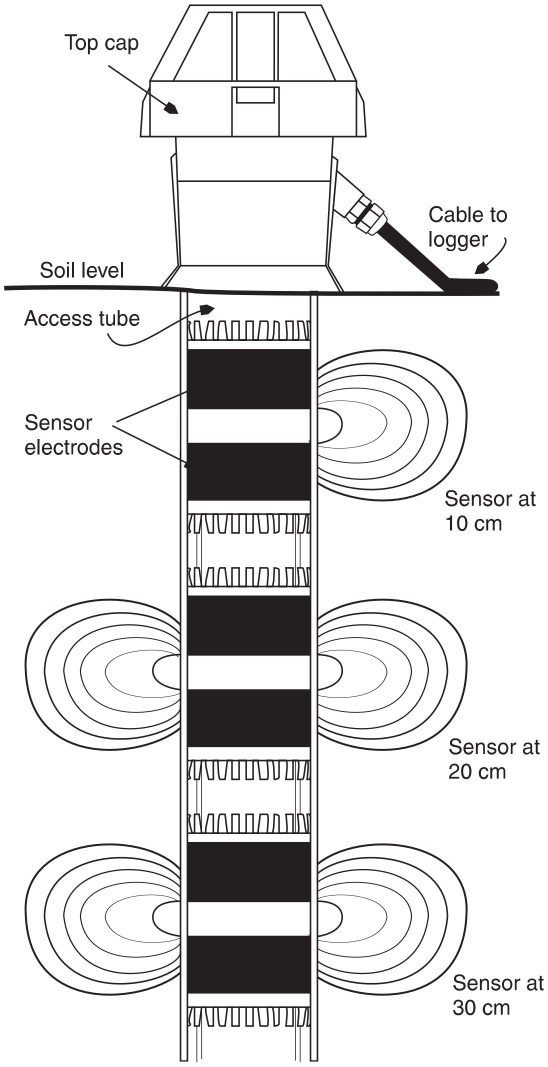

Figure 3. *Diagrammatic representation of an Enviroscan probe*

Pest management

Managing pests is probably the most difficult aspect of strawberry growing. This is because serious pests will inevitably occur at some stage in the life of the crop and these pests have the potential to destroy fruit yield and quality. Here are the things you need to know:

The problems with the traditional approach

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

- It was a waste of money if the pests were absent.
- Even when pests were present, it disregarded the fact that plants can tolerate small numbers of pests without significantly affecting yield and quality. In these cases, the cost of spraying is much greater than the benefit gained by controlling the pest.
- It increased the risk of chemical burn to the fruit.
- It was costly with up to 30 chemical sprays being applied each season.
- It relied heavily on new chemicals being developed to replace those for which insects develop resistance. This contradicts the modern reality where fewer new chemicals are being discovered and developed.
- It exposed the farm family and farm employees to a range of toxic chemicals.
- It increased the amount of chemical residue in both the fruit and the environment.
- It actually induced some problems such as spider mites.

A new approach: Integrated Pest Management

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

The key elements of IPM are:

- use of cultural control measures such as crop hygiene and crop rotation
- use of biological control measures such as naturally occurring or introduced parasites and predators of the insect pests
- use of chemicals only where necessary. Preference is given to chemicals which are compatible with the beneficial insects and 'softer' on the environment
- careful application of chemicals with well calibrated spray equipment to avoid crop damage, excess residues and off-site pollution
- checking the crop regularly to determine when pests are present. Only when they are present and at damaging levels, are chemicals or other control measures applied. This process of checking the crop to determine the need for control measures is called monitoring. You can do this yourself with some training but we recommend the use of professional pest monitoring services.

IPM works by first determining pest action levels - pest populations at which damage is considered worthy of attention. The action level can be thought of as the point at which the damage is roughly equivalent to the cost of control.

Pest populations are then accurately monitored and control measures applied only when pest populations approach or reach this action level. Monitoring then continues to allow pest populations to be managed at or below this action level. As well as the pests, the beneficial insects and mites which naturally attack the pests are also monitored. This is done because in some cases, they alone will be sufficient to keep the pest populations in check.

Monitoring pests

more info
Names of pest monitoring services Section 6 page 5

As mentioned earlier, the use of professional pest monitoring services is recommended. If you wish to do it yourself, it is suggested that you first get some training from a consultant. The main requirements for monitoring are:

- good eyesight and a hand lens, magnifying glass or small microscope
- time each week to inspect the crop
- a good knowledge of the pests and beneficial insects and mites.

Start monitoring a week after planting and continue once a week until the end of harvesting. Monitoring is not difficult and is really just a process of systematic observation and recording. It involves dividing the crop into blocks of about 5000 plants and then walking through each block in a pattern as shown in Figure 1. As you walk, search plants for signs of caterpillars, slugs and other damage.

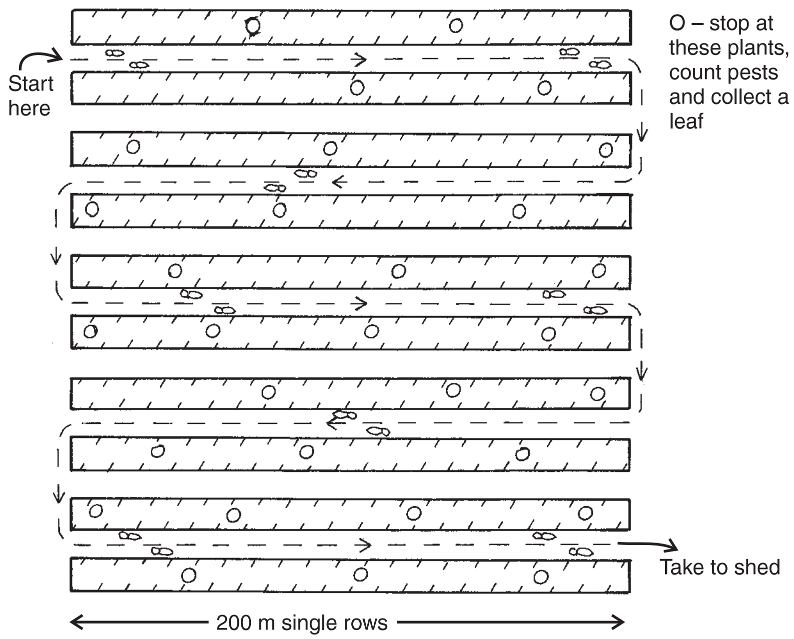

Figure 1. *How to monitor a 5000 plant strawberry patch*

Search 30 plants selected at random more closely. Gently brush the leaves to see if any insects fly out and carefully look at the leaves and flowers for signs of pests. This will also help identify any 'hot spots' of pest activity that you might miss from a distance. Take one leaf close to the plastic as shown in Figure 2 and put it in a plastic bag for later examination in the shed. These leaves are sampled to check on the level of spider mites, which are difficult to see in the field.

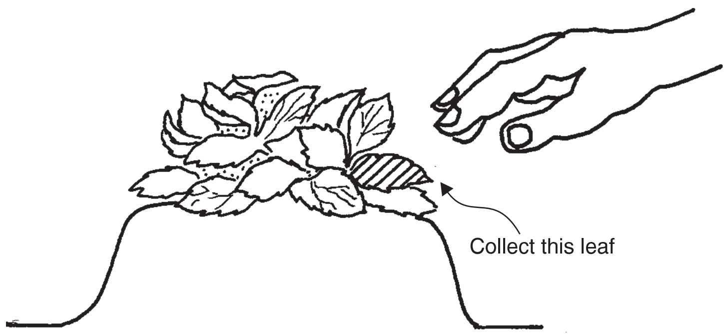

Figure 2. *The right leaf to sample for spider mites.*

In the shed, examine the lower surface of the leaves one by one under the hand lens, magnifying glass or microscope and record the numbers of mites present. Make up a recording sheet like the one in Figure 3 to help you with the monitoring. Record on it the number of discovered pests. Use a different set of 30 plants each time you sample.

Date: 7/6/96		Block: Kabarla		No. of plants in block	5000
Plants infested with caterpillars	Plants infested with slugs	No of Rutherglen bugs in flowers	Mites per leaf	Aphids per leaf	Other
I I	I I I I I I		3 1 0 2 0		Bird damage 2 fruit Leaf spot starting in bottom corner

Figure 3. *Sample recording sheet for use when monitoring*

The insect, slug and mite numbers recorded are then compared with the action levels shown in Table 1. Pest levels below the action level are not considered damaging enough to warrant the cost of management measures. Pest levels above the action level mean that some action should be taken immediately to prevent further pest buildup.

Table 1. *Action levels for strawberry pests*

Pest	Action level	Preferred action *
Cutworm	More than 1 plant in 200 damaged	Spray with endosulfan
Caterpillars (cluster, Heliothis, looper)	More than 1 plant in 200 infested	Spray with Delfin (cluster, looper) and carbaryl (Heliothis)
Spider mites	Either 5 or more spider mites per leaf or 7 of the 30 sampled leaves have any mites	Introduce predatory mites (to end of August) otherwise spray with Vertimec or Torque
Aphids	45 or more aphids per plant	Spray with Pirimor
Rutherglen bugs	5 or more per fruit or flower	Spray with endosulfan
Slugs	5 fruit per 100 m of row damaged	Apply snail/slug baits
Bud nematode	More than 1 in 100 plants affected	Apply Nemacur granules

* Details in *Problem Solver Handy Guide*.

Using predatory mites to manage spider mites

When the action level for spider mites is reached, there are two options:

- spraying with a chemical
- using biological control by introducing predatory mites.

The second option is preferred and recommended. This option reduces chemical residues on the fruit, eliminates fruit burn which is likely from mite control chemicals, and provides more effective control. Here are the main guidelines for using predatory mites:

more info

Predatory mite suppliers
Section 6 Page 5

- Monitor plants weekly and act as soon as the action level is reached. If for some reason the level of mites suddenly jumps above the action level (for example, eight or more of the 30 sampled leaves are infested or there are seven or more mites per leaf), spray first with a miticide and wait four days before releasing predators.

- Apply any other chemicals at least four days before releasing predators unless the chemicals are 'predatory mite friendly'.
- Irrigate with overhead sprinklers just before release to create a favourable environment for the predators. Do not overhead irrigate for three days after release.
- Do not release during rain or if rain is imminent. Keep the predators in their container in the bottom part of the fridge (two days maximum) until rain has finished.
- Keep predators out of the sun until release and release in the cooler part of the day.
- Introduce the equivalent of two predators per plant. This means placing one part of the three-part bean leaf, on which the predators are growing, in about every tenth plant. Tuck the bean leaflet under the strawberry leaves. Place more bean leaflets in hot spots.
- Mark the release sites with a paint mark on the plastic.
- The predators may be hard to find for a week or so and will take about eight weeks to bring the spider mites under complete control.
- Do not apply fungicides for two days and insecticides for two weeks after release. Use only chemicals safe for the predators. These are listed on the back of the *Problem Solver Handy Guide*.
- There is no point in releasing predators after mid August as they only begin to exercise control as the picking season is coming to a close. Instead use chemicals when action levels are reached.

Once predators are established, overhead watering enhances the predators and slows down the spider mites.

The 'pest-in-first' system for spider mite control

Although the predatory mite system described above works well in most instances, there are still ways in which it can be improved. One very interesting modification is to artificially infest crops early in the season with spider mites, creating artificial hot spots into which predatory mites can be later introduced. This technique is referred to as 'pest-in-first' (PIF). It may seem nonsensical to introduce a pest into the crop, but it actually has some sound thinking behind it. Here is the rationale behind the technique:

- Spider mites will inevitably infest all strawberry crops and so PIF is an effective way of getting in early and facing up to the inevitable.
- If you let nature take its course, spider mites generally build up to the action level in about late June or July. Getting predators established at this point is difficult. The humidity is often low which does not favour establishment. There are often other pests present requiring chemicals which are unsafe for the predators as they are establishing. In addition, predators may be more difficult to obtain at this later point in the season. By releasing predators early, these

problems are avoided and the timing of release is more decisive. Well established predators are then better able to cope with adverse weather and the more toxic chemicals.

- With the traditional random release of predators into a natural scattered distribution of spider mites, predators often perish because they are not close enough to their prey. By introducing predators to the spots where spider mites were previously released, PIF guarantees that they will have sufficient prey to get established and then continue controlling the spider mites. Results are therefore more predictable and certain.

The PIF strategy

more info
Names of pest consultants
Section 6 Page 5

Note: because PIF is a complex process, the use of a pest consultant is recommended, at least for the first season while you are learning the system.

Here are the steps:

1 Plant in March/April.
2 Encourage good leaf growth. Well grown plants provide a good environment for the predators. Monitor for caterpillars and spray where necessary for the first four to eight weeks.
3 In mid May, release spider mites. Spider mites may be obtained from pest consultants or predatory mite suppliers. Release spider mites on a 5 m by 10 m grid by placing an infested leaf under a plant at each grid site. Mark the release plants with a peg or a paint mark on the plastic. Alternatively, use the plants adjacent to sprinkler risers as the release plants.
4 Two weeks later, release the predators into the same plants. These plants may suffer some damage from the heavy infestation of spider mites but can be regarded as sacrificial plants.
5 Continue to monitor plants weekly, particularly between the grids and after any sprays to check that everything is operating smoothly.
6 Try to avoid any chemicals unsafe for the predators for at least six weeks after introduction. A listing of safe and unsafe chemicals is shown on the back of the *Problem Solver Handy Guide*.
7 If humidity is low for some days, short bursts of overhead irrigation will provide a favourable environment for the predators.

Spray application

The 'pest-in-first' system in particular, and IPM in general, rely heavily on the strategic use of chemicals which are compatible with beneficial insects and 'softer' on the environment. It is important that the number of these sprays is minimised to avoid unnecessary exposure of beneficial insects to chemicals. This means that every chemical spray needs to reach its target and achieve maximum impact. This requires efficient spray application.

Efficient spray application means obtaining good coverage of both leaf surfaces, but particularly the lower leaf surfaces, with approximately 70 to 100 droplets per square centimetre. Droplets should be around 50 to 120 micrometres in diameter (1000 micrometres = 1 mm). Better deposition of the droplets is generally obtained when they are carried to the target in a turbulent air stream.

Three types of sprayers are considered capable of efficient spray application:

- powered hydraulic sprayers (single row hand held boom; multi-row tractor mounted boom)
- air assisted boom sprayers (for example Vast Duel Air Curtain; Hardi Mini-Variant)
- controlled droplet sprayer (for example Micromaster)

These sprays need to be configured properly to ensure appropriate spray placement and adequate spray penetration. Example configurations for a powered hydraulic spray boom and an air assisted boom are shown in Figures 4 and 5.

HINT

Some consultants provide spray calibration services. If you want to do it yourself, details are available in DPI's Pesticide Application Manual.

Once you have an appropriate sprayer, you then need to calibrate it regularly and maintain nozzles and other components in good working order.

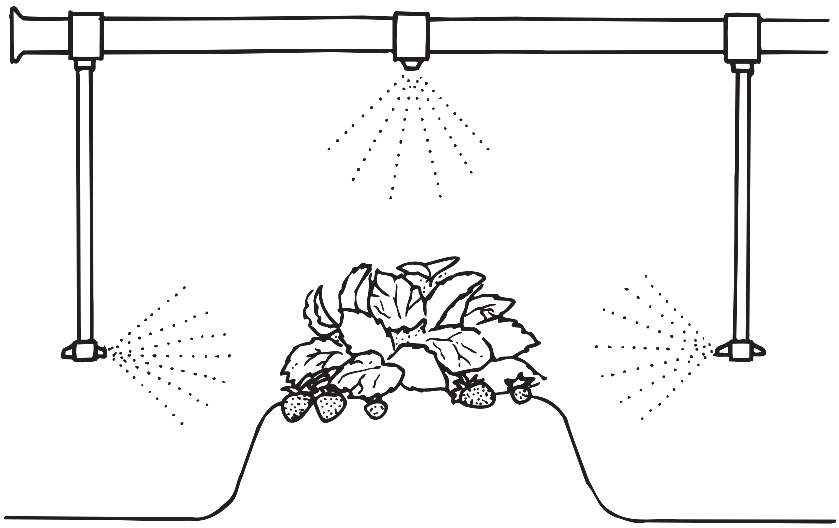

Figure 4. *Configuration for a powered hydraulic spray boom.*

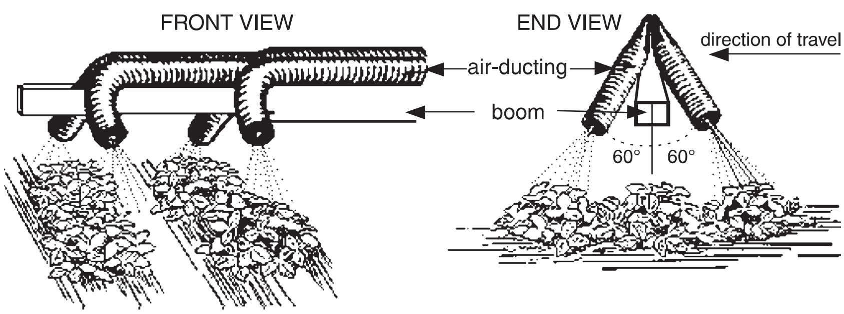

Figure 5. *Configuration for an air assisted boom.*

Alternatives to methyl bromide

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

The immediate problem with methyl bromide

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

This is being implemented through Australia's involvement as one of 149 nations which are signatories to an international agreement called the *Montreal Protocol on Substances that Deplete the Ozone Layer*. Through this Protocol, it was agreed in 1995 to completely phase out the use of methyl bromide in Australia by 2010. This is being achieved by the Commonwealth Government progressively restricting imports of methyl bromide over the period to 2010. The policy is being administered by the Federal Government agency, Environment Australia.

Pros and cons of methyl bromide

These are the main advantages of methyl bromide:

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

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

Possible alternatives

The range of possible alternatives for methyl bromide are listed in Tables 1 and 2. Some are practical alternatives, some are still highly theoretical and are only included to give a complete picture.

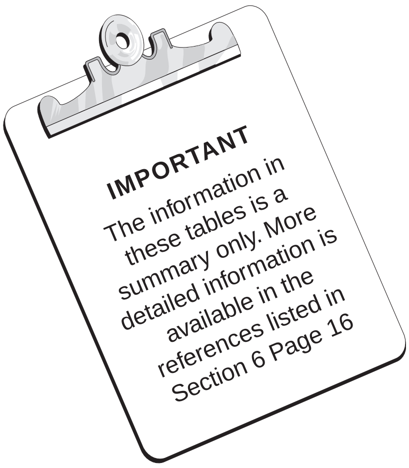

Table 1. *Chemical alternatives*

Chemical	Effective against:			Current status
	Diseases	Nematodes	Weeds	
Metham, Vapam	✓	✓	✓	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.
Telone II		✓		Good nematode control but future uncertain.
Telone C-17	✓	✓		Good nematode control but future uncertain. Limited by 2 to 3 week plant-back period.
Fungicides such as Ridomil, thiram, Benlate etc	✓			Effective against some specific diseases but limited by cost, potential disease resistance and rapid degradation in soil.
Nematicides such as Nemacur, Mocap, Vydate		✓		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 2. Non-chemical alternatives

Treatment	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.

From Tables 1 and 2, it will be seen that practical alternatives are limited at this stage. There is no other registered or existing chemical that has the same attributes as methyl bromide. So there is no easy shift to another chemical. Many growers see metham or Vapam as the only current alternative but it is doubtful if this represents a long term solution. The last twenty years has seen the demise of five or more fumigants—current ones may also go the same way.

Future strategies for the grower

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

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

- Think of your soil not as an inert medium to support the plants, but rather as a living fertile system in which soil bacteria, mycorrhizae, 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.
- 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.
- 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.

Marketing

Marketing is one of the vital issues in successful strawberry growing but regrettably one which is often seen to be secondary to the issues related to growing the crop. But marketing is probably the issue that will make the biggest difference to your success as a strawberry grower. This section covers the main things you need to know. Most of the information relates to marketing fruit domestically in the main metropolitan wholesale markets as that is where most Queensland fruit is marketed. Some brief information on export and other markets is provided at the end of the section. Topics covered include:

The essentials of marketing

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

- you must know what the market wants
- you must gear your production and marketing system to deliver a product that meets those market needs
- you must be prepared to get involved in researching the market for new and improved opportunities.

Know what the main domestic market wants

more info
Market research reports Section 6 Pages 17, 18

Some helpful insights into the needs of the market can be gained from recent research conducted in various Australian markets. The full reports are essential reading but here are the main points to come out of them:

- Good taste is the main thing most consumers are looking for. Although most current varieties seem acceptable from time to time, the Redlands varieties and Chandler appear to have a consistently higher acceptability level. Parker is poorly regarded when it lacks full colour. Many consumers eat the fruit on its own so flavour is obviously very important.

- Most consumers regard the 250 g punnet as the preferred package size. There is a limited market for the larger 375 g plate, mainly because of its higher price, so this product needs specialised niche marketing. Larger punnets appear to have little demand in the main markets. A lidded 250 g punnet is used for the premium 5 to 10% of fruit.
- There is a high level of dissatisfaction (75% of consumers in one survey) with strawberry purchases. These problems relate mainly to poor quality, poor taste and short storage life. These were seen as the main barriers to purchase, not the price.
- There is a range of preferences for the different carton sizes—12, 20 and 25 punnet sizes. The 20 punnet carton still appears to be the most popular, but may be overtaken by the 25 punnet carton.
- XL and L fruit sizes are preferred and form the bulk of the market sales but there are niche markets for all sizes.
- As strawberries are regarded as an impulse buying line, presentation is very important. Consumers are attracted to punnets with even colour and fruit size. Attractive labels enhance appearance.

To summarise, it is obvious that the main demand is for strawberries that have good taste, good quality (free from blemish, good shelf life), XL to L fruit sizes, and attractively presented in 250 g punnets with even fruit colour and size. Quality is more important than price.

Where possible, back this up with your own research of the market.

Delivering the product that the market wants

Having established what the market wants, the next step is to gear your production and marketing system to deliver a product with those specifications. The only way of ensuring this is to have a quality management system at the farm level. Becoming part of one of the marketing groups or co-operatives that have quality management systems is the easiest way of doing this.

If you are not part of a group quality system, you can still do something about improving your quality management. Here is the process you need to follow:

1 Learn about quality management. Read as much as you can about the subject and attend training courses where these are available.
2 Develop a plan which sets out the standards you want to achieve.
3 Share your plan with any staff (managers, pickers, packers) and ask for feedback. Involve staff at all stages from here on.
4 Critically analyse your current system for its strengths and weaknesses in meeting the standards. This may involve preparing a flow chart of operations, a hazard analysis and an organisational chart.
5 Develop new or modified operations to provide the quality standards you are seeking. These could involve field operations such as selection of varieties, management of nutrition, watering, pest and

disease control, prevention of wind damage, picking etc., as well as packing, handling and refrigeration operations after harvest.

6 Train your staff in the quality system and make your quality standards clearly visible to all by displaying them on posters.
7 Carefully record all field operations so you can see exactly what you have done should problems arise.
8 Appoint a quality auditor (or be that person yourself) to audit your quality management system and make sure it is working. This can be done by randomly selecting for inspection a sample of each grade of each consignment. About one carton in every 25 needs to be inspected. Check this sample of fruit for all facets of quality. Record these objective assessments. Keep a sample of fruit aside in the cool room so you can check its marketing characteristics in a few days time when your consignment will be in the hands of the retailer and consumer. Also ask your wholesale agent to provide feedback on the quality of your fruit.

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

New and improved market opportunities

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

- Consider getting together with other growers to develop group cooperative marketing under a common quality management system. Through the longer lines of consistent quality produced under this system, access is possible to market segments unavailable to most individual growers.
- Groups should consider using a professional marketing coordinator, particularly for export markets. A coordinator maintains close contact with all of the markets throughout Australia and overseas. The product can then be directed to each market based on the coordinator's intimate knowledge of how much it can handle before it is oversupplied and prices fall. The coordinator may also undertake market development and promotion on behalf of the group. By the coordinator handling all of the marketing decisions and problems, growers are allowed to concentrate on what they do best—growing quality fruit.
- Consider any value adding opportunities such as development of convenience products. Remember that consumers now are better educated, more health conscious, and are demanding more convenience in their foods.

- Support any market research proposed by your industry as it will greatly benefit your future marketing opportunities.
- Support any promotional activities implemented by your industry, including those aimed at improving fruit handling and shelf life in the wholesale and retail markets. These will increase sales and potential returns.
- Look for specialist strawberry wholesalers who present a positive enthusiastic impression particularly when things are tough. Wholesalers who specialise in seven or eight products normally develop more expertise in the product and should do a better marketing job than generalists.

Export market opportunities

Queensland has some strengths in the export market for strawberries. It is close to Asian markets, its skill base enables good quality fruit with a clean, green image to be produced, and its production is counter seasonal to most northern hemisphere producers. As a result, exports are growing, albeit slowly at this stage.

These are the problems it needs to contend with:

- **Quarantine barriers.** At present, quarantine barriers exclude export to Japan, USA, Korea, China, India and the Philippines. This leaves the main available markets at present as Singapore, Hong Kong, Thailand, Malaysia, some Pacific countries, Middle East and Europe. The Asian markets appear to present the best prospects for Queensland fruit.
- **Air freight costs and limits.** When combined with the high costs of production, this means that the product needs to build a reputation at the top end of the market.
- **Lack of continuity of supply.**
- **Consistent quality in line with market requirements.** There are a range of niche market opportunities available in south-east Asia. The requirements of each need to be carefully identified and a production/handling system developed to meet these requirements. It is necessary to either study the market in-situ or find someone here in Australia with that knowledge.

Pick-your-own and farm tourism

There is increasing interest in this form of marketing as a result of two developments. The first is Queensland's increasing tourism industry and the increasing interest in ecotourism and farm tourism. The second development is the increasing interest in farm based activities as leisure for local people. For growers exploring these options, here are some of the important things you need to consider:

- location—main road frontage preferred
- signage
- all weather access and car parking
- broad spectrum appeal for the visitor— may need a variety of other fruits and attractions
- value adding of strawberry products
- long season to make it viable
- very good PR on the farm
- good building and farm layout
- local authority requirements
- public liability insurance
- toilets and other amenities

Serious prospective growers may need to run their enterprise as a farm tourism business rather than a strawberry growing business.

Hydroponic strawberry growing

Most of the Queensland strawberry crop is grown in a conventional way in the ground using fertilisers applied to the soil. Increasing interest is being shown in hydroponic strawberry growing where plants are grown without soil in bags or troughs suspended above the ground, with all nutrients supplied by liquid fertiliser solutions. This has some advantages but also a range of problems. Some hydroponic growers have failed because they did not understand these limitations. This section is a brief summary of the key points that prospective hydroponic growers need to be aware of.

The advantages of hydroponic growing

Here are the main advantages of hydroponic growing compared to conventional ground culture:

- By elevating the plants to a better working height, it is much easier and more comfortable to establish the crop, look after it and then harvest the fruit. In fact, it is generally understood that in a well constructed hydroponics operation, the picking rate is more than doubled compared to conventional ground culture. As the fruit also stays cooler because of its elevation, it can be harvested later into the day without adversely affecting quality.
- There are generally few problems with diseases. Root and crown rots are rare as there is no contact with soil. Similarly, there are less fruit rots. Some pests such as slugs are virtually non-existent. In addition, there is less weather cracking of fruit as it dries more quickly after rain. Fruit can also be kept cleaner as there is no soil or sawdust in the vicinity. All of this means that there should be a better recovery of high quality fruit.
- As soil type and drainage are irrelevant for hydroponic production, cheaper land can be used. Frost-prone land also presents less risk as the elevation of the plants well above ground level provides a warmer environment by approximately 3 to 4°C.

- As hydroponics provides the opportunity for tiered plant arrangements, higher planting densities (up to 100 000 plants per hectare) can be used. Although yield per plant in these high density systems is lower, there is potential to increase the yield per hectare. This more intensive production means that the construction of capital works such as windbreaks, water reticulation, frost control etc is more economical per unit of production.
- As water and nutrients can be recirculated in a hydroponics system, it is much more efficient in water and fertiliser use than a conventional ground system.
- There are no weed problems in a hydroponic system.
- The elevation of the plants above ground level makes it easier to achieve good spray penetration into the plants.
- Although the capital costs of establishing plants is higher in hydroponics, savings can be made in the area of specialised machinery. For example, there is no need for a large tractor, bed former, mulch layer, fertiliser spreader, sawdust applicator or land preparation equipment. A smaller, less expensive sprayer is generally all that is required. Fumigation is also not necessary.

The problems with hydroponic growing

Here are the main problems with hydroponic growing compared to conventional ground culture:

- In hydroponic culture, there is a higher risk of failure as the whole system is much less forgiving than conventional ground culture. For example, pump failure on a hot day in a non-media system can result in rapid death of the plants. The conventional soil system allows much more room for error. Hydroponic growers need to be able to provide at least daily attention to their system.
- As the management of nutrients and water is much more critical, there is a need for a higher level of crop management skill. Again, the conventional soil system is able to buffer the plants against many water and nutrient imbalances. Hydroponic systems need to be much more finely tuned. Growers therefore need better knowledge of the plant and its management requirements.
- There is a higher risk of spreading diseases, particularly in recirculating systems. The highest risk is from diseases spread in water such as Phytophthora root and crown rot. Excellent hygiene is essential.
- Hydroponic systems require higher quality water. This is because plants are exposed directly to salts in the water and are much more vulnerable to damage. By comparison, soil provides a natural buffer or filter against some of these problems.
- The elevated plants in a hydroponic system are more susceptible to wind damage. This reduces yield and fruit quality. Good wind-

breaks are essential. Elevated fruit hanging from plants is also more susceptible to attack from Queensland fruit fly. Additional sprays for this pest are often required.

Myths about hydroponic strawberry growing

Fascination with the technology of hydroponics has led to some greatly exaggerated benefits of hydroponic strawberry growing. Here are some of the common statements and our responses:

- **Hydroponics will give a significant increase in yield.** Possible but not generally obtained in practice. Many prospective growers make the mistake of assuming that per plant yields remain the same when moving from a low density conventional system into a high density hydroponic system. The fact is that as plant density increases, yield per plant generally decreases. This is the case in both conventional and hydroponic systems. As a result, yields per hectare for similar plant densities are generally comparable between the two systems. It is possible to achieve higher per hectare yields with hydroponics by well designed tiered plant arrangements, and it has been achieved by experienced growers. But this should be seen as the exception rather than the rule.
- **With hydroponics, you can manipulate the plant and get year round production.** False. Under normal climatic conditions, the plant will behave exactly the same as in conventional culture. This is because the factors that control flowering and fruit production in most varieties are daylength and temperature. Neither can be effectively manipulated in hydroponics without complete climate control. This is not considered viable for strawberries.
- **Taste and keeping quality in hydroponic strawberries is better.** Generally false. Taste and keeping quality are principally determined by the genetics of the variety and not by the growing system. There is some limited opportunity in hydroponics to manipulate fruit quality characteristics by better nutrition and root temperature management but the results are not considered significant at this stage.
- **Hydroponic strawberries bring higher prices.** Generally false. Strawberry buyers select fruit on the basis of fruit appearance, flavour, perceived keeping quality and other quality characteristics. As there are no significant differences in these characteristics between fruit grown under the two systems, buyers generally do not discriminate between hydroponic and conventionally grown strawberries. It is possible to develop a specialty market niche for hydroponic fruit where they differ from conventionally grown fruit but this requires the grower to invest significantly in market development.
- **It costs a lot more to get into hydroponic strawberries than conventionally grown strawberries.** False. While the costs of

establishing the plants is higher because of the need for tanks, pumps, channels, nutrient meters etc, this is offset by the savings in other capital costs. For example, cheaper land can be used and there is no need for most of the specialised farm machinery necessary for conventional ground culture. Most economic analyses show that when these factors are considered, overall capital and start-up costs are similar.

Before you start

HINT

The proceedings of the first South Pacific Hydroponics Conference for intending growers is essential reading. Details of this and other reading are in Section 6 Pages 16–17.

more info

Hydroponic consultants Section 6 Page 7

Here is a list of our tips for prospective hydroponic strawberry growers:

- A fascination with hydroponic technology is not a good basis for commercial success. You also need skill and experience in commercial strawberry growing. The most successful hydroponic growers are generally strawberry growers who use hydroponics rather than hydroponic enthusiasts who grow strawberries. For this reason, first get some experience in conventional strawberry culture by growing some commercial crops yourself or working for a conventional strawberry grower.
- Start small (about 5000 plants) and learn how to manage the crop before your operation becomes larger.
- Read as much as you can on the subject and study the things that have made growers successful. Also join hydroponic grower associations so that you can receive advice and information from other experienced growers. Do a hydroponics study course where these are available. Local TAFE colleges often provide courses on hydroponics. The Queensland Distance Education College offers an excellent correspondence course.
- Plan carefully by examining such things as the suitability of your site and water supply, your management capability and your proposed market. Do a business plan to analyse what you are getting into financially. Use realistic expectations for yields, running costs etc—don't expect that you will do better than anyone else. Use a reputable hydroponic consultant to help you plan and then set up the system.
- Be prepared to dedicate yourself to your operation for seven days a week until you have an appropriate management strategy in place. This may take some years to develop. Remember that hydroponic systems allow little room for error and you must respond quickly to any problems.

Brief notes on the main systems

There are two main types of hydroponic system with a number of variations within each. These are summarised in Table 1.

Table 1. Types of hydroponic systems

	Closed systems	Open systems
Operation	Nutrient solution recirculated through pipes or channels	Nutrient solution run to waste (no recirculation)
Variations	**Continuous recirculation:** • NFT (nutrient film technique) **Intermittent recirculation (flood and drain):** • Gravel in pipes • Rockwool in pipes	• Hanging bags • Media in pipes • Media in modules
Advantages	• Conductivity and pH of solution easier to manage • Control of water easier • NFT allows opportunity for root heating	• Control of nutrients easier • Less risk of disease spread • Best for salty water • Cheaper to get into • Can achieve high densities with hanging bags
Problems	• Disease can be easily spread throughout entire system • Risk of salt buildup if nutrients not managed accurately	• Wetness in lower sections of bags, pipes or modules can kill or retard plants • Uneven nutrient distribution within media

Illustrations of closed and open hydroponic systems are shown in Figures 1 and 2.

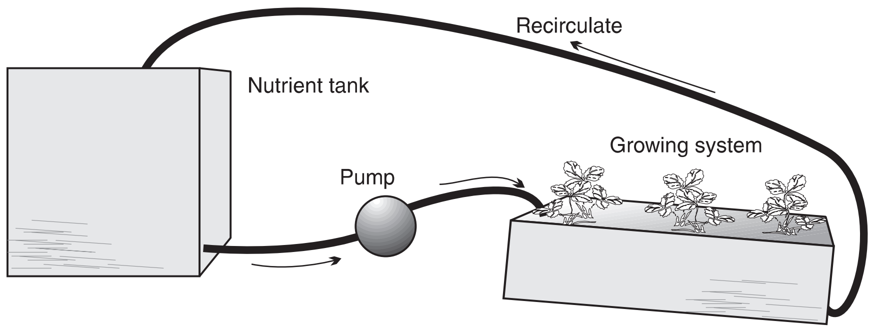

Figure 1. *Closed recirculating system*

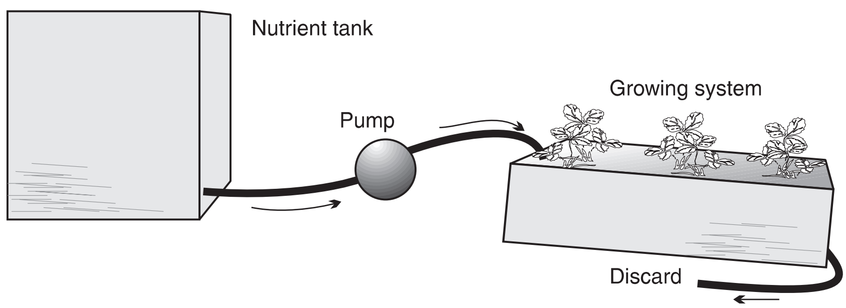

Figure 2. *Open run to waste system*

Closed systems (nutrient recirculation)

NFT - Nutrient Film Technique (continuous recirculation)

In this system, plants are grown bare root in a nutrient solution continuously recirculating in pipes or channels. The nutrient solution is fed into the top of a sloping pipe or channel and flows down through the roots in a thin film to the end where it is caught and aerated before re-use. The thin film allows oxygen to be continually incorporated into the solution.

Because strawberries spend a long time in the system (up to eight months), pipes or channels have to be big enough to allow for extensive root growth without clogging the system. A rectangular channel at least 150 mm wide is preferred. Support is necessary to prevent young plants from being blown out by the wind and later to prevent the crowns from getting too wet. If narrower pipes or channels are used, slope must be steeper (3 to 4% minimum) and the length no more than about six metres. These should only be used for shorter term plantings.

Gravel or rockwool in pipes (intermittent flood and drain)

In this system, plants are grown in gravel or rockwool within pipes or channels with the nutrient solution intermittently flooded through the system. At the end, it is caught and aerated before re-use. The rockwool option is preferred as gravel tends to heat up too much in the sun. One common system has plants in rockwool pieces about 75 mm square and 125 mm high placed within pipes about 110 mm in diameter. Holes of about 75 mm are cut in the top of the pipe to allow the rockwool pieces to be inserted. The pipes are positioned on tables or in tiers. Another system uses rectangular channels with lids containing plant holes. Rockwool slabs are placed within the channels and the lids replaced. Plants are then placed into the rockwool slab.

For small plants, the system is flooded once or twice a day and for larger plants, five or more times a day. The duration of flooding is generally one to two hours.

Open systems (run to waste)

These systems consist of bags, pipes or boxes containing a soil-less medium and fed with a nutrient solution by drippers. When the nutrient solution reaches the end of the container, it is not collected for re-use and allowed to run to waste.

Hanging bags

Hanging bags are made up from irrigation fluming of about 150 mm diameter. Bag length varies but is generally about 1.5 metres long. The bags are heat sealed at one end and filled with a suitable medium (generally a mixture of peat, perlite and crushed polystyrene) and suspended vertically from a strong trellis. Drainage holes are placed above the seal at the bottom. Two drippers or microtubes, one at the top and and a second in the centre of the bag, supply the nutrient solution. Holes are cut in the side of the bag to take the plants. The normal configuration is four rows of 5 to 6 plants about 25 cm apart. Rows of bags should be placed in a north-south orientation.

Nutrient solution is regularly fed into the bags to keep the media moist. As there can be considerable weight in the bags when wet, the trellis or support structure needs to be well designed. Support posts of 100 mm diameter are normally required at least every six metres with strainer posts of 150 mm diameter. Support wire should be 12.5 gauge high tensile.

Media in pipes/channels

Although this is commonly used by hobbyists, it is not reommended for commercial growers because the media remains too wet in the bottom half of the pipe, retarding and sometimes killing plants.

Media in boxes or modules

There are many variations here, the most common being media in polystyrene boxes, rockwool in plastic bags, media in pillow bags etc. All can be viable provided there is sufficient depth and volume of media for the plants. However, unless the boxes or modules are elevated up on shelves, which is expensive, there is little advantage over conventional ground culture.

Nutrient solutions

Nutrient solutions are made from pre-prepared concentrated stock solutions. Two stock solutions are generally used because of chemical reactions which occur between certain nutrients in one solution. Equal volumes of the two stock solutions are then diluted to make up the required volume of nutrient solution. There are a couple of options for how to get started with nutrient solutions:

- Make up your own stock solutions from individual nutrients (see Table 2).
- Make up your own stock solutions from pre-made nutrient mixes supplied commercially.
- Buy commercially prepared stock solutions.

more info

Details of reference book
Section 6 Page 15

Table 2 provides a recipe for stock solutions commonly used for strawberries in a recirculating system. The recipe was initially developed by David Huett, NSW Agriculture, Alstonville and subsequently modified by grower experience.

The nutrient solution is made up by mixing equal volumes (3.4 litres) of each stock solution per 1000 litres of water. Top up with the same mix.

Some growers have found benefit by adding potassium sulphate at a rate of 20 g/L to Stock Solution B when mature fruit is being produced.

Table 2. Starting stock solutions for strawberries (recirculating)

Stock solution	Ingredient	Mixing rate in grams per litre
Stock solution A	Calcium nitrate (commercial)	150
	Iron chelate	5.6
Stock solution B	MAP	20 (if pH more than 6.0) 0 (if pH less than 6.0)
	Potassium dihydrogen phosphate	16.3 (if pH more than 6.0) 29 (if pH less than 6.0)
	Potassium nitrate	133.3
	Magnesium sulphate	80
	Boric acid	0.35
	Zinc sulphate	0.2
	Manganous sulphate	0.2
	Copper sulphate	0.035
	Sodium molybdate	0.01

Other precautions

Here are some other important things to be aware of:

- Make sure you have permanent, good quality water. It needs to have low salt levels (conductivity less than 400 microsiemens per centimetre; sodium less than 30 ppm for recirculating systems and less than 50 ppm for run to waste systems; chloride less than 50 ppm for recirculating systems and less than 70 ppm for run to waste systems), little or no turbidity and no organic matter. All water will need effective filtration and dam or creek water will also require sterilisation (chlorination to 1 mg/L residual chlorine). If muddy, it will also need clarification.
- As nutrient solutions can react with storage and reticulation materials, use non-reactive components throughout. These include fibreglass tanks and plastic or stainless steel fittings.
- Nutrient solutions appear to operate most effectively when they are kept within a pH range of 5.0 to 6.5 and a conductivity range of 1.0 to 1.3 dS/m (decisiemens per metre).
- Have a back-up pump and power source for use in an emergency.
- Maintain a high level of hygiene throughout the entire system. This includes such things as water sterilisation, prevention of soil splash, keeping dust blow to a minimum, thorough cleaning and sterilisation of components between crops and so on.
- Make sure you have good windbreaks.
- There is generally little yield benefit in exceeding 8.5 plants per square metre. Most plantings use a density of between five and seven plants per square metre.
- Use only certified runners which were grown in fumigated soil. Before planting, wash the roots thoroughly to remove any soil.

Organic strawberry growing

Most of the Queensland strawberry crop is grown using a mixture of organic and manufactured fertilisers and pesticides. There is increasing interest in more sustainable growing systems which reduce the use of the artificial inputs and concentrate more on natural or organic practices. This section contains some brief notes on organic growing systems for prospective growers.

Why the interest in organic growing systems?

There are a number of reasons why interest in these systems is growing:

- Some believe that there is excessive consumption of non-renewable resources such as fossil fuels, used for the manufacture of fertilisers and chemicals. These people believe that this consumption must be reduced.
- There is concern that artificial fertilisers and chemicals are polluting the environment to an unacceptable degree, affecting the quality of air, water and wildlife resources. Chemicals such as methyl bromide are being phased out of use for this reason.
- There is evidence of excessive degradation of the soil resource. Soil erosion, salinisation, acidification, loss of soil structure and falling organic matter levels are all evidence of this decline.
- Health concerns are leading some consumers to demand produce with lower residues of artificial substances. The fact that some of these consumers are prepared to pay a premium for this produce provides a price incentive to growers.
- Farmers are wanting to create a safer working and living environment for themselves and their families by limiting their exposure to toxic chemicals.
- There is increasing Government regulation of the use of chemicals and other farm inputs. In a number of cases, this has led to withdrawal of chemicals. The increased regulation also makes it more difficult for new products to be registered.

- Increased resistance of pests and diseases to chemicals is further eroding the arsenal of available chemicals.
- Some growers perceive that production costs can be reduced by converting to organic systems.

A perspective on changing to organic systems

Whether all of the above reasons for the increasing interest in organics are valid or not, it is important to point out that commercial strawberry production already uses a considerable amount of organic culture. Lime, organic manures and green manure crops form the basis of soil preparation. Many farms are monitored for insect pests, and non-chemical pest management measures, such as biological insecticides and predatory mites, are widely used. To extend this system to the stage where no manufactured fertilisers or pesticides are used, is difficult with existing technology, particularly on larger commercial farms. These are the main problems:

- Effective organic control measures for leaf diseases, fruit rots and at least one of the main pests, Rutherglen bug are limited. Leaf diseases and fruit rots can be controlled to some extent by the use of natural chemicals such as copper and sulphur but significant fruit loss could be expected in prolonged wet weather. Plant damage from these natural chemicals is also much more likely. Pests like Rutherglen bug can be partly controlled by the use of organic insecticides such as pyrethrum, but major damage to fruit will occur in some seasons.
- Organic fertilisers, being slow acting and unpredictable in their release of nutrients, make it difficult to develop an effective program to meet the nutrient needs of the plant. This results in reduced yield and fruit quality. It is also difficult to quickly correct nutrient imbalances when they occur.
- The increased incidence of fruit rots reduces the potential keeping quality of the fruit making it difficult to access high priced distant markets.

These constraints need to be taken into account when considering organic growing. It is important to remember that organic growing generally involves a trade-off between possible higher prices and reduced yield and keeping quality.

Myths about organic strawberry growing

The hype surrounding organic growing has led to some exaggerated claims about what can be achieved. Here are some of the common statements and our responses:

- **Organics is easy to get into. You cut out the use of chemicals and nature will do the rest.** False. Organic growing is not just simply a matter of replacing the artificial inputs such as chemicals—it is a highly complex and difficult to manage system requiring a high level of skill for success.

- **Organically produced fruit will provide me with better prices and returns.** False. The market for organic fruit is currently limited to a small percentage of consumers that are willing to pay a premium for fruit produced under this system. If this limited market becomes oversupplied, consumers then have the opportunity to be more discerning and may only pay a premium for fruit at the better quality end of the market. It is also a niche market where fruit have to marketed through known organic outlets. Poor prices may result if organic fruit is marketed through the large supermarkets, where most strawberries are sold, as organic fruit then has to compete with conventionally grown fruit which will invariably have better appearance and keeping quality. Returns are generally no better than conventional crops as reduced yields erode the advantage of better prices.
- **I've grown strawberries in the backyard and had few pest problems so I should be able to do this commercially.** False. Beware of the argument that non-chemical home garden methods can be duplicated on a commercial farm. The success in home gardens is only possible because of the small numbers of plants grown and the isolation from other patches of strawberries. A larger patch will attract more pests and make it easier for them to establish and multiply. Home gardeners are also not greatly concerned about yield, fruit appearance or keeping quality, whereas these are essential objectives of commercial growing.
- **Organically grown strawberries taste better.** Generally false. Taste is principally determined by the genetics of the variety and not by the growing system.

Before you start

For prospective organic growers, here are some useful tips:

more info
Useful references
Section 6 Pages 15 and 18

more info
Organic certifying organisations
Section 6 Page 4

- Read as much as you can on the subject and study the things that have made organic growers successful. Also join local organic grower associations so that you can receive advice and information from other experienced growers. Do an organic growing study course where these are available. Local TAFE colleges often provide such courses. Also contact certifying organic producer organisations for their information packs on standards and the processes for becoming a certified organic grower.
- Talk to as many growers as possible who are using organic methods. See if you can work for one for a period to learn the ropes. It is also useful to work for a conventional strawberry grower to gain an insight into the nature of the strawberry plant and its problems.
- Trial a small area first (about 5000 plants) and learn how to manage the crop before your operation becomes larger.

- Plan carefully by examining such things as the suitability of your farm, your management capability and your proposed market. Do a business plan to analyse what you are getting into financially. Use realistic expectations for yields, running costs etc.,—don't expect that you will do better than anyone else. Use a reputable consultant, where available, to help you plan and then set up the operation.
- Remember that the market for organic strawberries is a limited niche market and can be easily oversupplied. Study the market carefully and analyse how you will be able to maintain a premium if and when this happens.
- Select a farm which is isolated from other strawberry farms to prevent easy infestation of pests and diseases. Carefully check the history of the farm to ensure that the soil has not been contaminated with previously used persistent pesticides.

Some tips on growing organic strawberries

Once you elect to go ahead with organic strawberry growing, here are some useful growing tips:

- Grow the plants in small patches and grow other crops between the patches. On any piece of land, grow strawberries for one year only and then rotate with other crops for three years before replanting with strawberries.
- Improve soil health and organic matter levels before planting by liming, growing green manure crops and applying manures. Get a soil analysis done to check that you have nutrient levels right before planting. Forms of fertiliser that are generally acceptable include unadulterated lime, gypsum, dolomite, rock phosphate, rock potash, quarry dust, manures, blood and bone, mushroom compost, Epsom salts and laboratory grade trace elements.
- Plant certified runners only. Choose the most disease and pest resistant varieties.
- Monitor the patch at least weekly for pests and beneficial insects. Use an integrated pest management system including the use of predatory mites, naturally occurring beneficial insects, biological insecticides such as *Bacillus thuringiensis,* hand removal of larger caterpillars, use of pheromone traps for caterpillar moths, use of organic insecticides and fungicides such as rotenone (Derris Dust), Natrasoap, garlic and citronella sprays, pyrethrum and so on.
- Observe strict crop hygiene by regularly removing and burying diseased leaves and fruit. Do not leave discarded fruit in the walkways.
- Keep weeds around the farm mown at all times, hand weed around the plants and use sawdust or grass mulches between the rows.
- Use local market outlets where long keeping quality is not required.

Becoming certified as an organic grower

Having developed an organic growing system, growers may wish to seek certification as an organic grower. This guarantees their credentials as legitimate organic growers and provides a marketing advantage.

Certification is possible under a national standard for organic and bio-dynamic produce released by the Commonwealth Government in 1992. Although this standard prescribes minimum requirements for organic labelling for the export market, the same requirement for certification may at some stage be applied to the domestic market. In the meantime, it acts as the unofficial benchmark for certification for the domestic market. Certification is administered by national organic grower organisations that have been accredited by the Australian Quarantine and Inspection Service (AQIS) as the auditors of the export standard for the Government.

more info
Organic certifying organisations
Section 6 Page 4

Two grades of certification are available:

- Organic/Bio-dynamic—for those growers who have developed their property and management skills to an acceptable level
- Organic/Bio-dynamic in Conversion—for growers who are new to organic farming.

The process for certification

1. Obtain a copy of the standards and an application form from one or all of the certification organisations.
2. Read the details carefully and if you wish to proceed, complete the application and send it with the prescribed fee back to the certification organisation/s.
3. You should then receive a questionnaire which will ask for details on the history of the farm, your farm management skills and processes, the risk of contamination from neighbours etc.
4. Complete the questionnaire and return it with the required documents.
5. Your property will then be inspected and soil and produce samples collected for testing.
6. Certification will then be considered, perhaps after a period of compliance, and offered or rejected.
7. If you are accepted, you will receive a contract of certification which enables you to use appropriate labels and logos.
8. You are then subject to annual re-inspection.

Remember that achieving certification is not easy and may take some years to achieve.