

STRAWBERRY INNOVATION

# Australian Strawberry Good Practice Guide



# Contents

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# Introduction

Like most horticulture in Australia, the strawberry industry is driven to deliver high quality product, whilst operating in a sustainable and profitable manner. Doing this isn't easy! To help those that may be new to the industry or those seeking a reminder of best practice, we have put together a resource which provides clear guidelines and practical advice on the best management practices associated with the production of strawberries in Australia.

We hope the Australian Strawberry Good Practice Guide also provides a useful reference to those outside of the strawberry industry, which demonstrates that Australian strawberries are produced in an environmentally sustainable manner.

This Guide has been developed by the Strawberry Industry Development Team with input from technical specialists as required. It outlines the key principles

of effectively managing resources (such as water, soil and fertiliser), how to deal with pests and finally keeping your strawberries looking good once harvested. Each chapter provides clear objectives, recommended practices, signposts to other helpful resources online and a checklist of actions required to achieve your goal.

Further resources and electronic copies of each chapter are provided on the good practice page of the Strawberry Innovation website at [www.strawberryinnovation.com.au](http://www.strawberryinnovation.com.au).

We trust you share our vision of continual improvement within the industry and that you will find the Guide useful in achieving good practice.



# Land and soil management

## OBJECTIVE

- Improve soil performance
- Minimise soil loss and degradation

## WHY IS IT IMPORTANT?

### Soil structure

Good soil structure is vital for maximising soil water intake and plant growth, and minimising soil erosion.

Well-structured soils have a high proportion of large clusters of soil particles (water-stable aggregates) which are held together by organic matter. Bigger pores or air-filled spaces exist between individual aggregates of a well-structured soil (as seen in Figure 1-1). These pores remain open to receive water and nutrients and as a result, less water runs off the soil surface and plants thrive.

To promote good soil structure, care must be taken to minimise aggregate breakdown and encourage high organic matter levels. Frequent cultivation, faster tractor ground speed and heavy machinery all contribute to the destruction of soil aggregates and the break-down of soil stabilising organic matter. Working on soil that is too wet or too dry makes the problem worse.

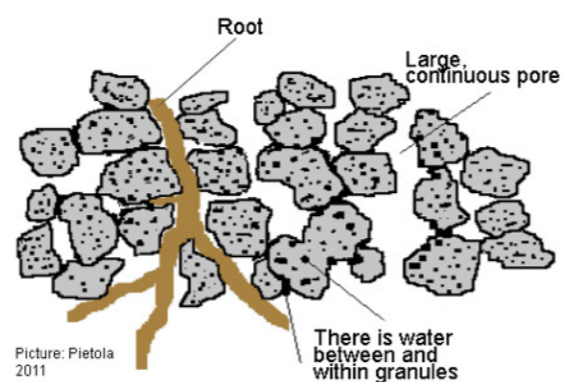


FIGURE 1-1: WELL STRUCTURED SOIL

## Land and soil management

To maintain and improve good soil structure you should establish an appropriate crop rotation, increase organic matter in the soil and follow good tillage practices, such as controlled traffic or minimum tillage programs.

can happen as a consequence of heavy rain, excess irrigation, or when drainage water from paddocks, farm tracks, protective cropping structures and areas around sheds and buildings moves across the land.

When water, either as rainfall or irrigation, falls faster than the soil can absorb it, it begins to flow over the soil surface. Flowing water, particularly when concentrated down bare slopes, has the potential to pick up and transport detached soil particles and associated nutrients. If the soil is covered with vegetation or mulch, raindrops are intercepted and soil particle detachment and splash are avoided.

### Keeping soil in its place

Soil can move from your farm as a result of water erosion, when water comes in contact with exposed and/or unstable soils (soils with poor structure). Erosion





## Land and soil management

Evidence of water erosion may include:

- Rills, gullies and tunnels
- Turbid water in farm dams or leaving the property, and
- Soil build up on fence lines or at the bottom of slopes.

To manage soil erosion caused by water, identify sites on your property that are at risk and if necessary, put control measures in place. Control measures include maintaining soil cover, controlling run-off water, improving soil structure and establishing

### Increasing soil organic matter

Increasing soil organic matter is central to improving soil performance. Soil organic matter contains carbon which is the energy source for microbial activity in the soil.

Soil properties can be grouped into three components, physical, chemical and biological (Figure 1-2).

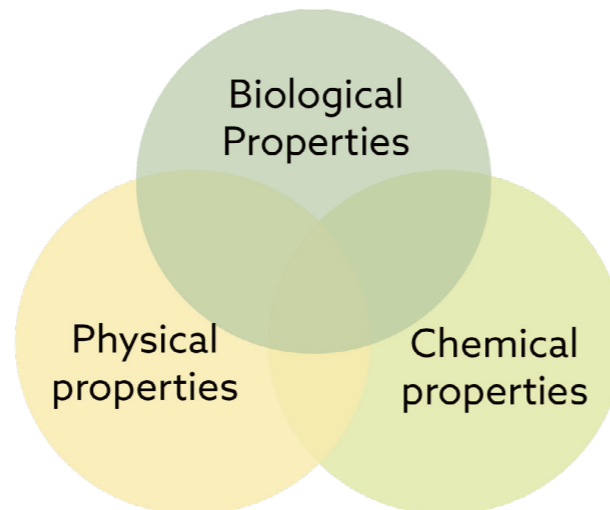


FIGURE 1-2: THREE COMPONENTS OF SOIL HEALTH

All three components must be managed to maintain or improve soil health. Soil organic matter is the most important component of your soil. It has potential to improve both the physical and chemical components of soil whilst improving:

- Crop performance and crop quality
- Nutrient and irrigation efficiency
- Infiltration and reducing compaction
- Nutrient holding and reducing nutrient leaching
- Pesticide efficiency

Improving soil performance through increased organic carbon, will improve strawberry productivity and help address environmental concerns.

## Land and soil management

Soil organic carbon can be increased by the use of:

- Composted organic amendments
- Cover crops
- Reduced and alternative cultivation practices
- Selective 'safe' pesticides.



### RECOMMENDED PRACTICES

#### Soil testing

Soil testing is a practical way to get a snapshot of soil health on your property. Soil testing is often done



prior to planting a crop. It is also useful to conduct regular testing to follow changes in soil properties over time and under different management practices.

The results from soil testing can be used to optimise plant growth or assist in solving soil-related problems. Soil test results can be useful to guide management practices, such as deciding



## Land and soil management

whether to fertilise. They can also indicate problem areas in your soil, such as excess salts, high or low pH, problematic soil texture and adverse nutrient levels.

It is important to remember that a soil test report is only as good as the care taken in sampling, with the sampling method effecting the usefulness of any results.

Further information on soil sampling and testing can be accessed from the good practice page of the Strawberry Innovation website.

### Management of cultivation and traffic

Frequent cultivation, fast tractor speed and heavy machinery all contribute to the destruction of soil aggregates and the break-down of soil stabilising organic matter. Working on soil that is too wet or too dry increased the problem.

Implementation of a minimum tillage approach is best practice. Minimum tillage is the minimum soil manipulation

necessary for successful crop production. Key elements of minimum tillage in strawberry production include:

- Reducing cultivations to the minimum essential number through the establishment of permanent or semi-permanent beds
- Minimising the number of passes by combining operations such as hilling up and ripping wheel tracks
- Controlling traffic in the block to specific traffic lanes or rows
- Avoiding steep slopes and/or degraded areas
- Choosing tyned and non-inverting implements that are sharp and correctly adjusted.

The moisture level of your soil during tillage has a major effect on soil structure. Using heavy machinery when soils are too wet or dry should be avoided. Ideal moisture levels depend on soil type and texture. Cultivation should occur when moisture content makes the soil feel friable.

## Land and soil management

### Soil cover

Soil cover protects the soil from erosion by reducing the displacement (movement) of soil particles caused by rain or overhead irrigation droplets, and by slowing the movement of water across the site. It also slows and filters sediment from incoming rainfall or irrigation runoff, improves the movement of traffic, offers a cleaner environment for workers and promotes cleaner fruit by reducing soil splash.

Types of soil cover include:

- Grassed waterways on drainage and sump areas
- Inter-row groundcovers between strawberry mounds
- Green manure/cover crops planted

between (in space and time) commercial crops

- Organic mulches, plastic, slashed inter-row material or crop residues spread over the exposed soil, and
- Products such as PAM (polyacrylamide), PVA (polyvinyl acetate) or molasses that bind soil together.

### Drainage management

At times water runoff is unavoidable and as a result structures need to be positioned to ensure soil and nutrient losses are kept to a minimum. Controlling the direction of flow, volume and speed of water run-off on site can reduce soil erosion.





## Land and soil management

Types of soil cover include:

- Minimise the volume of external drainage affecting the site
- Prevent irrigation/rainfall runoff from hitting or moving over bare soil
- Create stable pathways that slow runoff water and allow any nutrient-laden sediment to drop out before it leaves the property or enters watercourses or dams
- Evaluate the need for and design of various drainage management strategies (grass headlands and buffer, cut-off drains, diversion banks, and grassed waterways).

Careful design, construction and maintenance of farm tracks is also essential to minimise sediment and nutrient movement. The compacted and exposed nature of farm tracks makes them vulnerable to erosion. Good planning and design at the outset can prevent many problems later.

### Remedial action

If a hard pan or compaction layer is present, then additional cultivation may be needed. If the condition is not due to sodicity (high sodium content), cross-ripping when soils are friable will help to



shatter the pan, loosening and breaking clods that will break down further when exposed to the weather. The benefits of deep ripping can be short term (around 1 year) unless actively growing roots enter the fracture lines.

Areas of active erosion should be managed through restricted access, reduced water flow and soil stabilisation through the establishment of vegetative cover.

Further information on managing cultivation and traffic, soil cover, and drainage can be accessed from the good practice page of the Strawberry Innovation website.

## Land and soil management

### Crop rotation

Rotating crops can improve soil structure, with crops such as grasses and legumes increasing the pore spaces through your soil. Deep-rooted crops can also recycle excess soluble nutrients like nitrate and sulphur from deeper in the soil profile and these crops add organic matter as the deep roots eventually break down. Roots help break up the soil and create pores to assist with movement of water through the soil.

Using green manure crops to increase organic matter will provide soil structure benefits through better soil aggregation. Decomposing plant material or organic matter produces gums and resins which assist in binding soil particles together

to form aggregates and pore spaces. This helps optimise the soil's water-holding capacity, ability to hold nutrients, workability and water infiltration.

### Soil amendments

Soil organic carbon provides many benefits for soil health including improved soil structure and aggregate stability, improved nutrient availability and providing a food source and habitat for organisms that live in the soil.

The organic carbon content of soil is the balance between inputs of carbon rich material (plant growth and additional material) and losses through decomposition, erosion and product removal. Where inputs are greater than losses, soil organic carbon increases.





## Land and soil management

Soil organic carbon is influenced by a range of management practices that provide carbon inputs (including increasing biomass production, retaining crop residue and crop rotation/green manure crops) or decrease carbon losses from the soil (including reducing erosion and cultivation).

Applying high carbon soil amendments such as compost, biochar and some manures is also an effective way to increase soil organic carbon. Soil amendments can also be used to address specific soil limitations such as a lack of nutrients.

### Selective 'safe' pesticides

In focusing on developing soil carbon levels, the use of pesticides is an important consideration. Soil biology is critical to managing soil organic carbon and can be seriously disrupted by a range of pesticides, including herbicides.

Further information on crop rotation and soil amendments can be accessed from the good practice page of the Strawberry Innovation website.

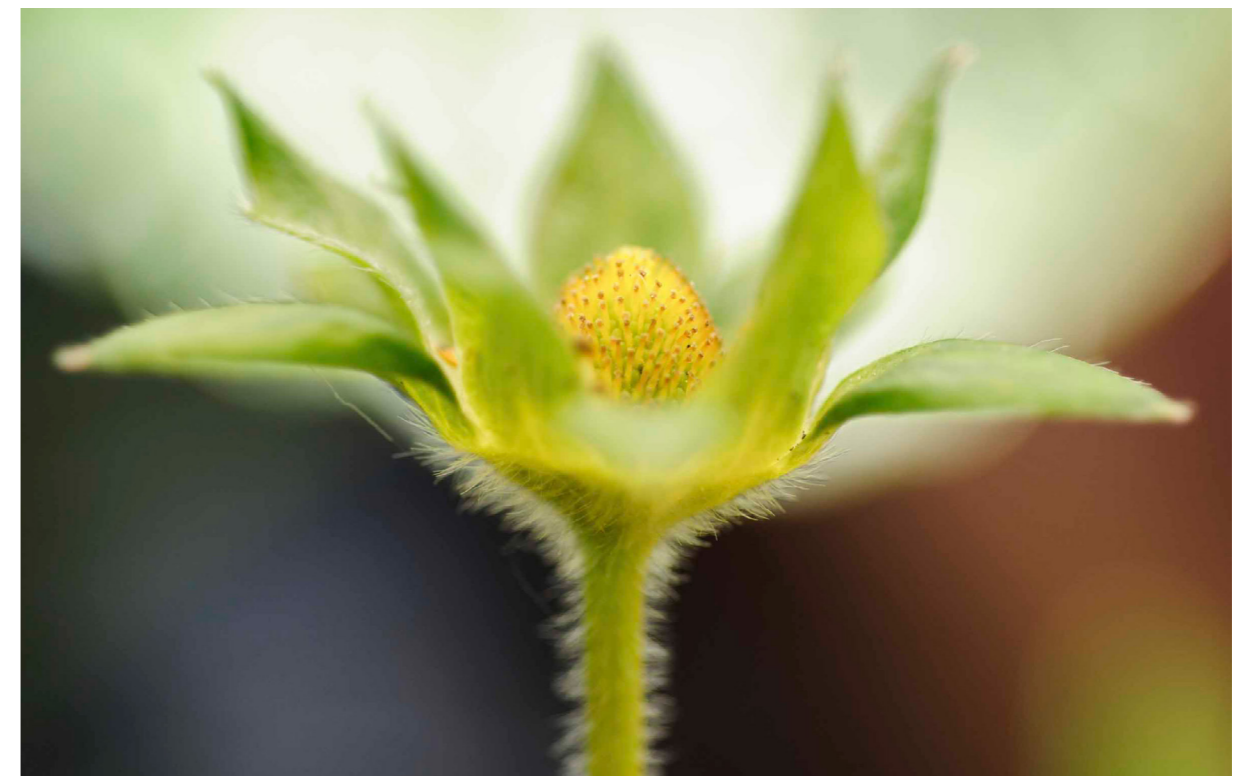


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There is an increasing number of selective pesticides which include biologically active material such as the bacterial caterpillar control chemistry based on *Bacillus thuringensis*. These 'softer' pesticides have reduced knockdown capability compared to some conventional pesticides and therefore should be integrated into a pest management program.

Herbicides can also be detrimental to soil biology and particular care in selecting 'safe' chemicals will be an important element of using and managing cover crops.

To read about how John Hasan is managing his soil health, go to the good practice page of the Strawberry Innovation website.





# Land and soil management

## LAND AND SOIL MANAGEMENT PRACTICE CHECKLIST

The following checklist provides a quick, easy and actionable way to assess how well you are aligning your land and soil management to the recommended best practice.

TABLE 1-1: LAND AND SOIL MANAGEMENT PRACTICE CHECKLIST

| RECOMMENDED PRACTICES  | YES | NO | N/A | ACTION REQUIRED IN THE NEXT 12 MONTHS |
|--|-----|----|-----|---------------------------------------|
| Do you:  |     |    |     |                                       |
| Test the soil regularly (for pH, organic matter, nutrient levels, salinity, sodicity)?     |     |    |     |                                       |
| Implement a minimum tillage approach and time cultivation with ideal soil moisture levels? |     |    |     |                                       |
| Rotate crops to include additional cash crops, green or biofumigation crops?               |     |    |     |                                       |
| Apply soil amendments such as compost, biochar or manure?                                  |     |    |     |                                       |
| Maintain soil cover within cash crops and between cash crops?                              |     |    |     |                                       |
| Have safe stable pathways that slow runoff water?  |     |    |     |                                       |
| Improve the condition of eroded or degraded soil?  |     |    |     |                                       |
| Use selective 'safe' pesticides?   |     |    |     |                                       |

# Land and soil management

## HELPFUL RESOURCES

Healthy Soils for Sustainable Vegetable Farms: Ute Guide (Anderson, Kelly and McKenzie, 2007): <http://www.hort360.com.au/wordpress/wp-content/uploads/2015/03/Healthy-soils-for-sustainable-farms-Ute-Guide.pdf>

Soil Wealth and Integrated Crop Protection Website: [www.soilwealth.com.au](http://www.soilwealth.com.au)

Building Soils for Better Crops: <http://www.soilwealth.com.au/resources/article-publication/building-soils-for-better-crops/>

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Nicholls, Z., Layden, I., Bagshaw, J., Stockwell, B., Grobler, L. (2008). Strawberry best soil, water and nutrient management practices, Department of Primary Industries and Fisheries, The State of Queensland

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## PHOTO CREDITS

Image 1 and 5: Marty McCarthy 2015 ABC Rural

Image 4: Green Lake Sanitary District 2017

Image 6: Josiah Hunt 2010

## STRAWBERRY FAST FACTS

The best sites for soil-grown strawberries:

- Are well drained with at least 25cm of soil above any impeding layer
- Have a soil pH in water between 6.5 and 7.0
- Have salinity less than 1 dS/m (EC of saturated extract).



# Water management

## OBJECTIVE

- Maximise water use efficiency
- Maintain water quality on-farm and downstream

## WHY IS IT IMPORTANT?

### Water quantity

Water is becoming increasingly scarce and expensive, therefore using water in the most efficient way is an important part of business management. Poor irrigation practices are usually the biggest culprit in inefficient water use. Improving irrigation practices will facilitate water savings and lead to better long-term environmental outcomes.

Irrigation efficiency can be maximised by:

- Checking that irrigation systems are operating to design specification and applying water as evenly as possible.

- Ensuring that the timing, or irrigation schedule, is based upon crop water needs and a clear understanding of the soil's water holding, infiltration and drainage capacity.

Good irrigation management is also essential to maximise yield and manage product quality. Strawberry plants have a relatively shallow and fibrous root system with the majority of roots in the top 30 cm. Moisture stress can seriously impact on strawberry plants in the form of reduced yields, small fruit size and poor quality. Conversely over-watering can impact on yield through reduced soil aeration, increase in root diseases and reduced fruit quality. It is important to keep soil moisture at optimum condition,

## Water management

especially when the plant is flowering and developing fruit quality. The steps to maximising irrigation efficiency are discussed further in this chapter.

### Water quality

The quality of water used for strawberry production should:

- Be suitable for the intended purpose
- Not negatively impact on downstream users and the environment

Using poor quality water on-farm can lead to problems associated with salinity (high total soluble salt content), sodicity (high sodium content), toxicity

(high concentration of specific salts in the soil) and blue-green algae (which may be toxic, clog irrigation equipment and cause corrosion of pipes and other equipment). Irrigation water for strawberries must be excellent quality, as strawberries are very sensitive to salts. The presence of chloride will impact on yield, even at very low levels.

Poor irrigation practices, such as over-watering, can result in more water being applied to the crop than the root-zone can hold. The excess water either runs off the surface of the property, potentially entering wetlands and waterways; or infiltrates below the rootzone to deep drainage. If this water is of poor quality (contains contaminants such as heavy metals, agricultural chemicals or high salt levels) it can cause disruption and damage to surrounding ecosystems.

Effective management of water quality relies on regular monitoring of water quality entering and leaving the farm. Establishing buffers around dams and waterways is also an effective way to filter sediment and nutrients from water before runoff enters waterways.





# Water management

These techniques and others are discussed further in this chapter and in the land and soil management chapter.

Strawberries can be grown using recycled water if it is available in your production area but it must be of Class A quality to meet food safety requirements. Further information on using recycled water is available on the good practice page of the Strawberry Innovation website.



## RECOMMENDED PRACTICES

### Irrigation efficiency

The key steps to improving irrigation efficiency include:

1. Knowing your soil (and how much water it can hold)
2. Designing an efficient irrigation system (use an expert)
3. Developing a water budget (have you got enough?)
4. Developing an irrigation schedule (monitor soil moisture)
5. Monitoring and maintaining irrigation system performance (is it doing what it should?)
6. Maintaining an appropriate water quality (how will crops, irrigation equipment, and the surrounding environment be affected?)

# Water management

## 1. KNOWING YOUR SOIL

The type and texture of your soils will affect the amount of water readily available for crops and also the rate that water infiltrates the soil. A well-designed irrigation system increases water efficiency by minimising evaporation and avoids soil erosion by ensuring the application rate of the system is slightly less than the infiltration rate of the soil.

The infiltration rates of different soil types are shown in Table 2-1. To determine the texture of your soil using the ribboning technique refer to the good practice page of the Strawberry Innovation website.

For optimum water usage, it is important to be aware of the soil water-holding capacity in the root zone of a crop.

This is the amount of water in the soil between 'field capacity' (the point at which the soil cannot hold any more water) and the 'refill point' (the point at which soil moisture is so low that it slows crop growth and stresses the plants). Thus, the water-holding capacity of the soil indicates how much water is readily available for the crop.

The water-holding capacity or amount of 'Readily Available Water (RAW)' will vary with soil type (as shown above), crop rooting depth and irrigation system used.

Further information on how to calculate RAW can be found in the helpful resources section at the end of this chapter.

**TABLE 2-1: BASIC INFILTRATION TYPES AND WATER-HOLDING CAPACITY FOR VARIOUS SOIL TYPES**  
(Adapted from tables by Brouwer et al (1998) and Ramsey (2007))

| SOIL TYPE  | BASIC INFILTRATION RATE | READILY AVAILABLE WATER |
|------------|-------------------------|-------------------------|
|            | (mm/hour)               | (mm/metre)              |
| Sand       | >30                     | 30-40                   |
| Sandy loam | 20-30                   | 45-70                   |
| Loam       | 10-20                   | 50-90                   |
| Clay loam  | 5-10                    | 30-80                   |
| Clay       | 1-5                     | 25-70                   |



## Water management

Soil moisture monitoring equipment can be used to estimate the water holding capacity of a particular soil type. Using soil moisture monitoring equipment is discussed in the section on 'Developing an Irrigation Schedule.'

### **2. DESIGNING AN EFFICIENT IRRIGATION SYSTEM**

Ideally strawberry plants should be watered via combined systems of overhead and drip irrigation in conjunction with mulch to reduce evaporative losses. This combined system has the benefits of using less water, avoiding chemical wash-off, reducing leaf and fruit diseases, reducing fruit impact damage and allowing for effective fertigation. Drip irrigation is recommended throughout the season and overhead irrigation is recommended to assist the establishment of young plants, as a pest and disease suppressant or as a protection measure against heat.

#### Overhead irrigation

Overhead irrigation can be used to establish young plants (5 - 12 days after transplanting) and cool plants during times of severe heat.

When new runners arrive, they have no active roots. Reducing plant stress (wilting) by overhead irrigation promotes quicker root establishment and the take up of nutrients, enabling good plant growth. The frequency and duration of overhead irrigation will depend on the weather and condition of the runners at planting. Compact runners with smaller leaves require less irrigation as they have less leaf area than long large-leafed runners that lose water more readily.

If transplanting during hot temperatures (>30°C), cooling may be required 1-4 times an hour during the heat of the day until roots are established and drip irrigation becomes more effective. Irrigation at this level uses a lot of water. As the goal is cooling rather than irrigation, using low output micro-sprinklers can reduce water use by up to 60 per cent compared to impact sprinklers.

Drip irrigation should be used in addition to overhead irrigation during establishment to promote root establishment and prevent soils from drying out between planting holes.

## Water management

#### Use a designer

Irrigation efficient systems work best when the pipe sizes, mains, valves, laterals and filtration and fertigation systems all synchronise as part of an overall scheme rather than being simply added on. Irrigation Australia Limited (IAL) Certified Irrigation Designers (CID) have the technical expertise and an up-to-date understanding of the latest water management practices to design, install, manage and maintain a wide variety of irrigation systems. To find a CID near you, and to find more information on irrigation system design in general, visit the IAL website:

[www.irrigationaustralia.com.au](http://www.irrigationaustralia.com.au)

### **3. DEVELOPING A WATER BUDGET**

A farm water budget will help to determine if you have sufficient water to cover crop needs over the production season. Water requirements need to be budgeted using measurement of:

- crop water demand at different times of the year
- the irrigation system, and
- knowledge of the soil water holding capacity

Individual farm data is best, but average crop water demands can also be used. The total crop water requirement for strawberries has been estimated at 4.5-7 ML/ha depending on the irrigation system used.





# Water management

This total water requirement consists of 3.5-4.5 ML/ha for seasonal crop usage and 1-2.5 ML/ha for establishment watering (*Growcom – Water for Profit*).

An example of a water budget can be seen in Table 2-2.

### 4. DEVELOPING AN IRRIGATION SCHEDULE

Scheduling irrigation requires an understanding of how much water your soil can hold and how much of that water your crop can use.

Evapotranspiration (dependant on sunshine and wind) and the impact of rainfall are altered by plastic mulch

and structures such as protective cropping tunnels. Therefore, stand-alone evaporation-based irrigation scheduling does not work well for strawberries produced under these growing conditions. To determine how much and when to apply water to strawberry crops, it is best to monitor soil moisture. This can be done using a variety of soil moisture monitoring tools such as tensiometers, gypsum blocks or capacitance probes.

**TABLE 2-2: EXAMPLE OF A WATER BUDGET**  
(Source: Lovell (2006))

| AN EXAMPLE OF A WATER BUDGET:                         |              |                |                       |
|---|--------------|----------------|-----------------------|
| PROPERTY NAME:  |              |                |                       |
| YEAR:   |              |                |                       |
| INTENDED CROP:  |              |                |                       |
| Crop  | Variety      | Crop area (ha) | Water requirements/ha |
| Strawberry  | Red Rhapsody | 1              | 4 x 1 ha = 4 ML       |
| Strawberry  | Rubygem      | 2              | 5 x 2 ha = 10 ML      |
| Strawberry  | Camarosa     | 0.5            | 6 x 0.5 ha = 3 ML     |
| Total water requirement for the property              |              |                | 17 ML                 |
| Total water allocation for the property               |              |                | 20 ML                 |
| Sufficient water availability to grow intended crops? |              |                | Yes                   |

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When the soil is wet, the porous tip of the tensiometer or gypsum block allows water to move from the soil into the sensor, decreasing suction pressure or resistance. As the soil dries, water is sucked out, increasing the vacuum within the tensiometer and the resistance within the block. A reading of zero indicates saturated soil while below zero indicates a drying soil. Using this information, irrigations can be spaced to prevent tensions falling below desired levels.

Positioning of soil moisture probes is very important. If using drip irrigation, place sensors midway between a plant and a dripper. Probes will over estimate soil moisture if placed directly under a dripper. Place probes in a representative area of the crop and move them to different locations to confirm the reading before a final site is selected. A good setup is to have at least three probes, one measuring the top 15cm, one at 15-30cm and one below the root zone at 30-60cm (DAF, 2016).

In general, applying smaller volumes of water more frequently is far more effective than occasional

heavy applications. Irrigation should commence when the 15cm tensiometer reaches -15kPa on lighter soils and -18 kPa on heavy soils. Irrigation should be stopped when the 30cm probe responds. This will help to minimise deep drainage.

There is a range of equipment that can be used to monitor soil moisture. These include tensiometers, gypsum blocks, neutron probes, capacitance probes and synthetic blocks amongst others. They vary in cost, ease of use and ability to log data continuously. As with irrigation system design it is best to discuss your needs with a professional to determine what equipment will work best for you.

### 5. MONITORING AND MAINTAINING IRRIGATION SYSTEM PERFORMANCE

Irrigation systems should be regularly checked and maintained to make sure they are operating at maximum efficiency. Key performance indicators that should be monitored include irrigation water use, system outputs, distribution uniformity and soil readily available water holding capacity.



## Water management

Further information on maintaining a drip irrigation system is available in the helpful resources section at the end of this chapter.

### 6. MAINTAINING APPROPRIATE WATER QUALITY

The key steps to maintaining or improving water quality include:

- Checking the quality of water entering and leaving the farm
- Protecting local watercourses
- Minimising soil erosion
- Protecting water quality - how is crop management impacting on water quality?

Individual farm data is best, but average crop water demands can also be used.

### Water quality entering and leaving the farm

Check the quality of water used for irrigation particularly if starting a new enterprise. Good data should be available from your water supply provider. If using dam water consider doing a water test to determine salt levels. Remember that water quality will change throughout the year. Further information on the quality of water required for irrigation is provided in the fact sheet 'Irrigation water quality for strawberries'.



## Water management

It is also worthwhile checking the drainage and run-off water leaving your property. If the water is high in nutrients and turbidity (water cloudiness), consider how crop management may be impacting on your water quality. This is discussed further in the section on protecting water quality.

### Water quality entering and leaving the farm

Naturally waterlogged low-lying areas like drains, wetlands and vegetated areas along waterways (riparian area) should be retained and protected. These naturally-occurring zones trap, remove or treat a range of pollutants, including organic particles, suspended solids (SS),

nutrients, pathogens, heavy metals and other toxic particles. A vegetated buffer strip consisting of dense perennial grass or native grasses, shrubs and trees also slows down runoff and reduces the erosion potential of water entering the adjoining water course or stream. It is recommended that vegetated buffer strips are also established between cultivated areas and waterways as well as on drainage lines that feed farm dams. Further information on protecting local watercourses can be found in the land and soil management chapter.





# Water management

## Minimising soil erosion

Minimising erosion of soil helps to protect soils and maintain water quality. High turbidity of run-off indicates soil loss is occurring and is most common after intense rainfall. Buffer zones or grassed areas can help to filter run-off and storm water.

For further information on techniques to minimise soil erosion refer to the soil management chapter and associated fact sheets available on the good practice page of the Strawberry Innovation website.

## Protecting water quality

There are a number of crop management aspects which have the potential to negatively impact on water quality.

These include:

- Nutrient management (ensure that nutrients stay in the plant root zone by applying fertilisers appropriately. This is discussed further in the

nutrient management chapter and associated factsheets).

- Agricultural chemical management (store and apply chemicals properly – do not apply chemicals where they could drift into water).
- Pollution from fuels and oils (store and clean up fuel and oil spills appropriately – further information is provided in the chemical management chapter and associated factsheets).
- Packing shed water (monitor and if necessary filter used packing shed water to remove organic matter and chemicals before it is released back into waterways).

Further information on irrigation water quality can be accessed from the good practice page on the Strawberry Innovation website.

# Water management

The following checklist provides a quick, easy and actionable way to assess how well you are aligning to the recommended best practice.

**TABLE 2-3: WATER MANAGEMENT CHECKLIST**

| RECOMMENDED PRACTICES   | YES | NO | N/A | ACTION REQUIRED IN THE NEXT 12 MONTHS |
|---|-----|----|-----|---------------------------------------|
| <b>Do you:</b>  |     |    |     |                                       |
| Know the water holding capacity and infiltration rate of your cropping areas?   |     |    |     |                                       |
| Use an IAL Certified Irrigation Designer to design and install your irrigation system? The proper design of sprinkler and drip systems ensures that the rate of application does not exceed the soil infiltration rate. |     |    |     |                                       |
| Have a water budget for annual production?  |     |    |     |                                       |
| Know if your irrigation system can meet seasonal and peak water requirements?   |     |    |     |                                       |
| Undertake irrigation scheduling using continuous soil moisture monitoring with defined fill and refill points?  |     |    |     |                                       |
| Monitor irrigation system performance including measuring irrigation water use, system outputs, distribution uniformity and soil readily available water holding capacity?  |     |    |     |                                       |
| Check the quality of water entering and leaving your property?  |     |    |     |                                       |
| Retain existing drains, wetlands and riparian vegetation?   |     |    |     |                                       |
| Establish vegetated buffer strips between cultivated paddocks and waterways and on drainage lines that feed farm dams?  |     |    |     |                                       |



# Water management

## HELPFUL RESOURCES

Irrigation Best Practice. Water Management of Soil and Substrate-Grown Crops. A Guide for Top and Soft Fruit Growers: <http://www.ukia.org/pdfs/water%20management%20of%20soil%20and%20substrate%20grown%20fruit%20crops.pdf>

Irrigation Essentials Updated. Research and innovations for Australian irrigators. 2012. NPSI: <http://www.insidecotton.com/jspui/bitstream/1/1954/3/npsi06121-irrigation-essentials-updated.pdf>

Water for Profit Fact Sheets. GrowCom: <https://www.growcom.com.au/land-water/water-for-profit/resources-water-for-profit/>

Irrigation and fertiliser guidelines for strawberries. Department of Primary Industries and Regional Development: <https://www.agric.wa.gov.au/strawberries/irrigation-and-fertiliser-guidelines-strawberries>

Irrigation water quality for strawberries: <http://strawberryinnovation.com/production/2018/3/1/irrigation-water-quality-for-strawberries>

Using recycled water for strawberry production: <http://strawberryinnovation.com/production/2018/3/1/using-recycled-water-for-strawberry-production>

Determining soil texture using the ribboning technique. 2014. DPI NSW [http://www.dpi.nsw.gov.au/\\_data/assets/pdf\\_file/0005/164615/determining\\_soil\\_texture\\_using\\_ribboning\\_technique.pdf](http://www.dpi.nsw.gov.au/_data/assets/pdf_file/0005/164615/determining_soil_texture_using_ribboning_technique.pdf)

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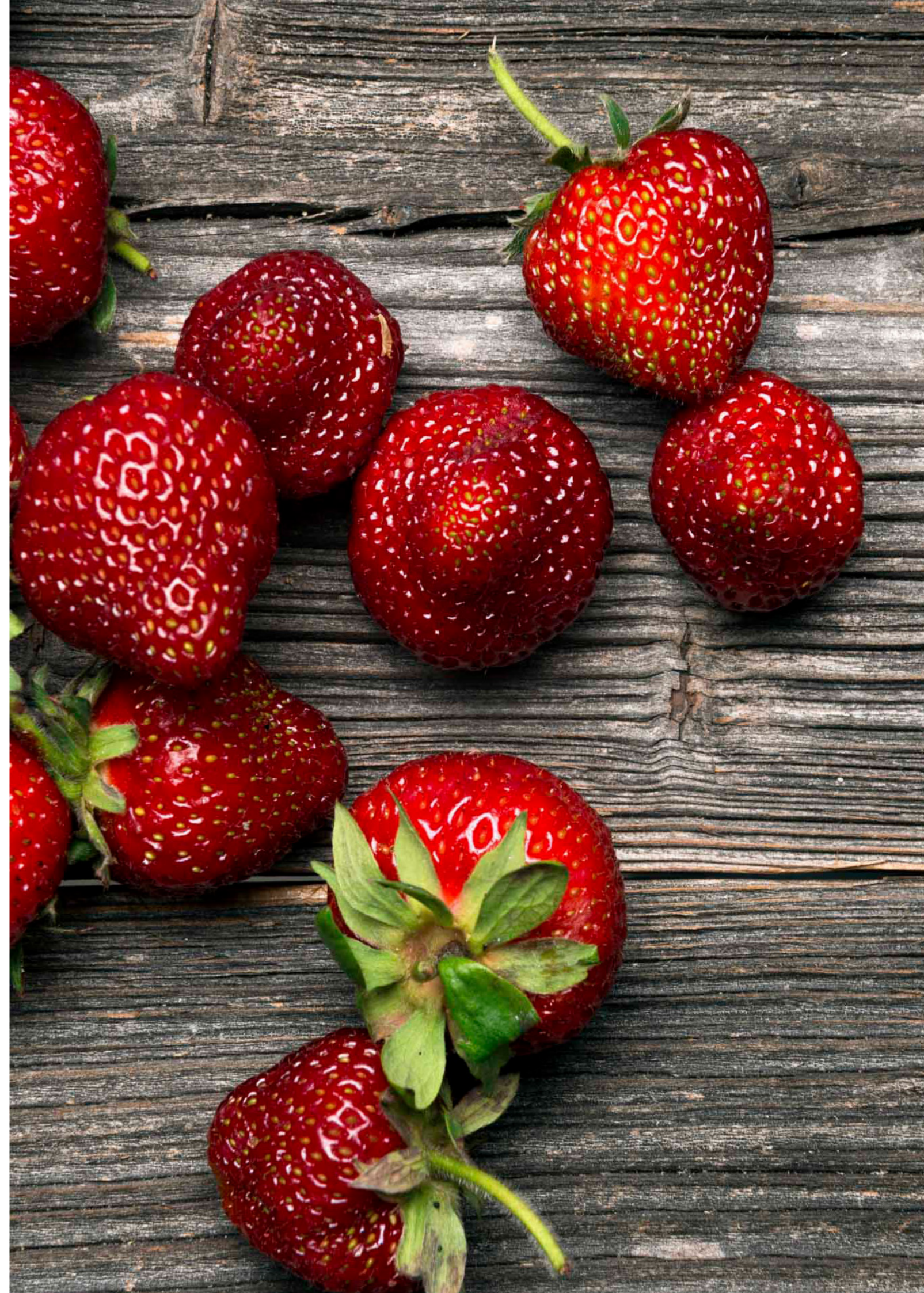
Water for Profit. Benchmark - Irrigating Strawberries. Growcom

## PHOTO CREDITS

Image: Green Lake Sanitary District 2017

## STRAWBERRY FAST FACTS

- Strawberries have shallow root systems with the majority of roots in the top 30cm of the soil profile. They respond better to frequent, smaller volumes of water rather than occasional heavy applications.
- Monitor soil moisture using three probes, one measuring the top 15cm, one at 15-30cm and one below the root zone at 30-60cm.





# Nutrient management

## OBJECTIVE

- The productive capacity of the soil is maintained without detriment to the environment

## WHY IS IT IMPORTANT?

Most Australian soils are naturally low in nutrients. Nutrients such as nitrogen, phosphorus and potassium are essential for strawberry plant growth and fruit production. However, application of excessive nutrients can be detrimental to the production of quality fruit, harmful to the environment and a waste of money. By carefully managing nutrient application and soil fertility, production targets can be achieved without environmental harm. This can have the added benefit of improving efficiency and reducing costs.

## Impacts on productivity and quality

Inappropriate management of plant nutrients can reduce productivity and the quality of fruit produced – including

poor colour, flavour and texture.

Nutrient deficiencies are not the only potential issue. Over-fertilisation of strawberry plants with nitrogen can also lead to excessive leaf growth which has implications on fruit yield, fruit firmness, fruit ripening, the effectiveness of applied sprays and disease control.

## Impacts on the environment

Environmental impacts from nutrient overload include degradation of groundwater and surface waterways, increase in soil acidity, salinity and sodicity problems and contamination of soil.

The nutrients most at risk of causing off-farm impacts are nitrogen and phosphorus. Nitrogen and phosphorus in dams, streams and rivers results in

## Nutrient management

eutrophication causing dense growth of plant life such as water weeds and algae which degrades aquatic habitat.

Nutrient movement away from the production area must be avoided. Most nutrient loss results from:

- Inaccurate application
- Leaching past the root zone and into groundwater
- Moving as dissolved nutrients in surface water leaving farm paddocks
- Attaching to soil sediments and within organic particles in surface water leaving farm paddocks

- Attaching to wind-eroded soil particles, and
- Evaporation into the atmosphere.

## Costs to farm businesses

For effective management of nutrient inputs it is important to determine the amount and type of nutrients to apply for each cropping situation rather than using recipe-type application rates. This can be done through soil testing and nutrient budgeting.

Inappropriate management of nutrients can lead to a range of costs to the farm





# Nutrient management

business, including:

- Loss of productivity and reduced yield
- Reduction in fruit quality
- Excessive and unnecessary application of fertilisers.

## RECOMMENDED PRACTICES

### Soil health

Good soil health is vital to ensure that plants are able to take up nutrients efficiently, as well as delivering a range of other long-term benefits. Good soil structure and root distribution as well as appropriate soil moisture management are prerequisites for any nutrition program. Organic matter management should also be considered to improve soil health and structure.

If soil structure, root growth and/or irrigation water quality are below optimum, nutrient availability and/or uptake will be affected. Further information on best practice for soil management can be found in the soil and land management chapter of this Guide.

### Nutrient requirements

Understanding the nutrient requirements for a growing cycle will help to inform a nutrient management program. Objective methods such as soil testing and leaf analysis, combined with information on soil type, variety, yield data and visual assessments of crop health, provide the basis for good fertiliser management.

Fertilisers should be applied efficiently, taking seasonal conditions into account. This means applying just enough nutrients for good crop growth without providing excess nutrients that may be lost off farm into groundwater and surface waterways.

Soil test results and optimum soil nutrient levels should be discussed with an agronomist or soil consultant. Based on this interpretation and consideration of soil type, cropping history, specific crop needs and agronomy, a written fertiliser recommendation should be provided. This may include recommendations for adding lime, dolomite or gypsum.

# Nutrient management

Leaf analysis can help to assess the nutrient status of berry plants in order to more accurately determine fertiliser requirements. The analysis provides an indication of the nutrient concentrations within the plant tissues, helping to identify deficiencies to guide nutrient applications. Visual assessment of plants can also provide information on nutrient status – see Table 3-1.



**IMAGE 3-2: STRAWBERRY LEAF DISPLAYING SYMPTOMS OF IRON DEFICIENCY**

**TABLE 3-1: VISIBLE SYMPTOMS OF PLANT NUTRIENT DEFICIENCIES**

| Symptoms                                       | Potential causes  |
|--|---|
| <b>Leaf symptoms</b>                           |   |
| Uniform yellowing                              | Nitrogen or sulphur deficiency (or poor soil drainage)              |
| Yellowing with green veins                     | Zinc, manganese or iron deficiency                                  |
| Dark and/or purpling foliage                   | Phosphorous deficiency  |
| Leaf scorch                                    | Potassium or magnesium deficiency (or spray burn and salt toxicity) |
| Growing points damaged with restrictive growth | Calcium or boron deficiency   |
| <b>Fruit symptoms</b>                          |   |
| Bumpy or misshapen fruit (poor pollination)    | Boron deficiency (or: frost damage, high temps during flowering)    |
| Hard/tight seed, small fruit                   | Calcium deficiency  |
| Soft, poor colour and flavour                  | Potassium deficiency  |

## Nutrient management



**IMAGE 3-1: TYPICAL SYMPTOM OF CALCIUM OR BORON DEFICIENCY. IT IS DIFFICULT TO DIFFERENTIATE BETWEEN THESE DEFICIENCIES IN THE FIELD.**



**IMAGE 3-2: TYPICAL SYMPTOM OF POTASSIUM OR MAGNESIUM DEFICIENCY. IT IS DIFFICULT TO DIFFERENTIATE BETWEEN THESE DEFICIENCIES IN THE FIELD.**

Sap testing can also be used to develop nutrient uptake graphs, so fertiliser applications can be timed to the

appropriate growth stage of the crop. Samples for sap testing need to be collected carefully and tissues analysed by an accredited laboratory.

For further information on how to collect leaf samples for analysis and new tissue nutrient reference levels for Victorian day neutral strawberries cv. "Albion" please refer to the Strawberry Innovation website.

### Nutrient budgeting

Nutrient budgeting can help growers better understand the whole nutrient cycling and transformation system. This can lead to the design of more sustainable, integrated nutrition strategies. Nitrogen, phosphorus and other major nutrients are the main elements considered in nutrient budgeting. Along with soil, leaf and sap testing and visual assessments, nutrient budgeting is another tool for fine-tuning the nutrient management program. A nutrient budget should be prepared for a 3-5 year rotation.

A nutrient budget is like an accounting system for nutrients. It involves capturing information about the nutrients coming in and out of the system (see Table 3-2).

## Nutrient management

The aim of the budget is to help ensure the appropriate levels of nutrition are available to support plant growth and fruit development through well-timed fertiliser applications. By understanding the level of uptake and removal in the target crop at a target yield (e.g. see Table 3-3), alongside the inputs/outputs outlined in Table 3-2, appropriate levels of additional fertiliser application can be calculated.

Nutrients that may be easily lost have to be applied as frequently as possible and amounts should be matched to the crop growth curve (rapid growth = higher demand) – so the timing/frequency of

inputs may vary through the growing season. Trained agronomists should be able to help interpret the results of soil testing and provide guidance on target yields given local growing conditions. The guidance can help growers develop a reliable nutrient budget.

### Nutrient application

#### Timing of applications

Applying fertilisers correctly is as important as using the correct amount and type of fertiliser. Effective fertiliser application involves the right rate, frequency, time and placement.

**TABLE 3-2: LEVEL OF NUTRITION IN THE SOIL BASED ON LEVEL OF NUTRIENTS EITHER ALREADY EXISTING, ADDED AND REMOVED FROM THE SOIL**

| Budget                 | Types of inputs / outputs  |
|------------------------|--|
| Existing nutrient pool | <ul style="list-style-type: none"> <li>Available nutrients in soils (based on soil results)</li> </ul>   |
| Inputs                 | <ul style="list-style-type: none"> <li>Nutrient applications — calculate the amount of nutrients already applied to the paddock (such as fertilisers, manures etc)</li> <li>Irrigation — calculate the amount of nutrients (especially nitrogen) that will be applied with irrigation water (50 ppm nitrate in irrigation water will add about 1 kg N/ha with every mm of irrigation water applied)</li> </ul> |
| Outputs                | <ul style="list-style-type: none"> <li>Uptake and removal by the target crop and the previous crop (in kg per tonne of grown crop)</li> <li>Environmental losses — estimate the amount of nutrients that will be lost to the environment (through run off, leaching, erosion, gaseous losses etc.)</li> </ul>  |



# Nutrient management

**TABLE 3-3: EXAMPLE DATA ON THE REMOVAL AND UPTAKE OF MICRO-NUTRIENTS BY OPEN-FIELD OR PROTECTED STRAWBERRY CROP**

|                        | N   | P <sub>2</sub> O <sub>5</sub> | K <sub>2</sub> O | CaO     | MgO |    |
|------------------------|---|-------------------------------|------------------|---------|-----|----|
| Removal (kg/MT fruits) | 6-10  | 2.5-4.0                       | 10-15            | 3.7-4.9 | 1.1 |    |
| <b>Yield level</b>     | <b>Uptake &amp; removal by yield levels (kg/ha)</b> |                               |                  |         |     |    |
| <b>8 MT/ha</b>         | Plants uptake                                       | 49                            | 21               | 83      | 29  | 6  |
|                        | Yield removal                                       | 15                            | 5                | 26      | 9   | 2  |
|                        | Total recommended application rate                  | 59                            | 68               | 108     | 15  | 6  |
| <b>16 MT/ha</b>        | Plants uptake                                       | 81                            | 34               | 138     | 48  | 9  |
|                        | Yield removal                                       | 30                            | 10               | 51      | 18  | 3  |
|                        | Total recommended application rate                  | 97                            | 83               | 179     | 24  | 9  |
| <b>25 MT/ha</b>        | Plants uptake                                       | 118                           | 48               | 200     | 68  | 13 |
|                        | Yield removal                                       | 47                            | 15               | 80      | 27  | 5  |
|                        | Total recommended application rate                  | 142                           | 100              | 260     | 34  | 13 |
| <b>30 MT/ha</b>        | Plants uptake                                       | 129                           | 51               | 218     | 75  | 14 |
|                        | Yield removal                                       | 57                            | 18               | 96      | 33  | 6  |
|                        | Total recommended application rate                  | 155                           | 104              | 283     | 38  | 14 |
| <b>35 MT/ha</b>        | Plants uptake                                       | 147                           | 59               | 250     | 85  | 16 |
|                        | Yield removal                                       | 66                            | 21               | 112     | 38  | 7  |
|                        | Total recommended application rate                  | 176                           | 113              | 325     | 43  | 16 |

Generally, applying small amounts regularly is less likely to cause off-site losses from leaching and run-off. Fertiliser applications should be scheduled according to seasonal conditions, cropping cycle and periods of greatest use by the crop.

See Figure 3-1 which outlines the 4R principle of nutrient stewardship.

# Nutrient management



**FIGURE 3-1: 4R PRINCIPLES OF NUTRIENT STEWARDSHIP**

### Pre-plant fertilisers

Pre-plant fertilisers should be incorporated. If there is a likelihood of heavy rain, minimise the amount of pre-plant fertiliser applied to reduce risks of fertiliser loss through leaching and soil wash from paddocks into nearby waterways. Band fertilising, or applying fertiliser to the top of prepared beds

prior to planting is preferred to general broadcasting, as it delivers the fertiliser close to plant roots.

### Fertigation

Use fertigation (the application of dissolved fertiliser through a trickle irrigation system) to apply macro elements (nitrogen, phosphorus, potassium, calcium and magnesium). Applying nutrients close to the plant root zone during the growing period in this way, ensures plant nutrient uptake is maximised and nutrient loss is minimised. Banded, slow-release fertilisers are also useful to extend nitrogen availability to the plant and reduce the nutrient leaching potential

† Source: La Malfa, 1992 and Haifa NutriNet

# Nutrient management

Restrict foliar applications of fertiliser to trace elements (boron, manganese, zinc and iron) unless specific macro deficiencies are evident.

## Bulk organic or inorganic fertilisers

If bulk organic or inorganic fertilisers are used, they should be incorporated immediately if possible (e.g. animal manures), or stored for the shortest time possible, far away from dams and water. If stored, use the same carefully selected, dedicated storage area all the time

and don't disturb stored heaps. Use a relatively impermeable site and minimise drainage movement into and from these sites by using diversion banks, cut-off drains and grassed buffers. Preferably protect the stored heaps from rainfall.

## Equipment

Fertiliser application equipment needs to be carefully calibrated and maintained to make sure it is capable of spreading fertiliser evenly at the correct rate. Refer to the manufacturer's specifications when carrying out calibration.

Detailed soil mapping can support precision application of nutrients using specialised equipment. This helps to identify areas within a field that require higher or lower nutrient inputs, allowing variable application rates to be used.

## Record keeping

It is recommended that an accurate record be maintained of all fertiliser applications, including foliar applications and fertigation. This applies both to organic (e.g. sheep, cattle, chicken manure) and inorganic fertilisers (e.g. superphosphate). Detailed, accurate records of fertiliser applications will help to construct an up-to-date nutrient budget.

Soil test results for the paddock and sap and leaf tests for the crop should also be kept to support these fertiliser records. Fertiliser application records are essential for nutrient budgeting.

# Nutrient management

## CHECKLIST

The checklist below provides a practical way to easily determine how you are tracking with nutrient management in relation to best practice recommendations.

TABLE 3-4: NUTRIENT MANAGEMENT CHECKLIST

| RECOMMENDED PRACTICES   | YES | NO | N/A | ACTION REQUIRED IN THE NEXT 12 MONTHS |
|---|-----|----|-----|---------------------------------------|
| <b>Do you:</b>  |     |    |     |                                       |
| Test the soil, plant tissue and plant sap prior to nutrient application?  |     |    |     |                                       |
| Prepare a nutrient budget for a 3-5 year rotation?  |     |    |     |                                       |
| Keep fertiliser records to assist future fertiliser management decisions?   |     |    |     |                                       |
| Implement appropriate application of fertilisers and amendments (type, rate, frequency, timing and placement fertilisers and amendments)? |     |    |     |                                       |
| Store fertiliser in a way that lowers the risk of seepage into surface waterways and groundwater?   |     |    |     |                                       |
| Ensure spreaders are correctly calibrated prior to use?   |     |    |     |                                       |
| Implement appropriate application methods of fertilisers and amendments (banding, fertigation)?   |     |    |     |                                       |



# Nutrient management

## HELPFUL RESOURCES

Further information on nutrient requirements, budgeting and application include:

The Haifa Strawberry Crop Guide

<https://www.haifa-group.com/crop-guide/vegetables/strawberry-fertilizer/crop-guide-strawberry-1>

The Strawberry Fertiliser Guide by NSW Department of Industry and Investment

[https://www.dpi.nsw.gov.au/\\_data/assets/pdf\\_file/0020/333362/Strawberry-fertiliser-guide.pdf](https://www.dpi.nsw.gov.au/_data/assets/pdf_file/0020/333362/Strawberry-fertiliser-guide.pdf)

Crop nutrient replacement: Calculator for fertiliser requirements

<https://www.dpi.nsw.gov.au/agriculture/horticulture/tropical/fertilising/replacement>

Horticultural fertigation – techniques, equipment and management

<https://www.dpi.nsw.gov.au/agriculture/horticulture/tropical/fertilising/replacement>

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## PHOTO CREDITS

Image 3-1: Ting

Image 3-2: Strawberry problem solver and bug identifier by Queensland DPI 2005

Image 3-3: Strawberry problem solver and bug identifier by Queensland DPI 2005

Image 3-4: Strawberry problem solver and bug identifier by Queensland DPI 2005

## STRAWBERRY FAST FACTS

- Good nutrient management can help to improve plant productivity and fruit quality, protect the environment and save money
- It is important to understand the nutritional requirement of your plants, and the level of nutrients available to them from their environment (e.g. through the soil, irrigation, and fertiliser applications)
- This information can help to develop an appropriate nutrition management plan, based on local conditions
- Agronomists or other suitably qualified experts can help to interpret soil test results and develop a nutrient budget





# Pest management

## OBJECTIVE

- Manage established pests in a cost effective and environmentally and socially responsible way

## WHY IS IT IMPORTANT?

Harmful pests can impact on food safety, trade, market access, market development and, ultimately, the profitability and sustainability of plant industries. Australia is relatively free from many of the plant pests which seriously impact on agricultural industries in other countries. Through the absence of many pests commonly found overseas, Australia's plant industries have a valuable competitive advantage in terms of securing market access and maintaining lower production costs. If these pests found their way into Australia, the economic viability of Australia's plant industries could be directly threatened.

Once pests (any harmful insects, diseases and weeds) are established, the methods used to manage them are also important. Integrated Crop Protection (ICP) also known as Integrated Pest Management (IPM) considers all available pest control techniques and other measures that discourage the development of pest populations, while minimising risks to human health and the environment. For growers, ICP is the best combination of cultural, biological and chemical measures to keep weeds, insect pest numbers, disease pressure, and other crop production problems low enough to prevent significant economic loss.

## Pest management

By adopting management practices that effectively implement site-specific strategies for plant biosecurity and ICP, strawberry growers can contribute to the long-term protection and profitability of the industry. Working towards sustainable agriculture by implementing cost-effective, environmentally sound and socially acceptable ways of managing established and emerging pests and diseases will in the long run be beneficial to all growers.

## RECOMMENDED PRACTICES

### Biosecurity

Plant biosecurity is a set of measures designed to protect a crop from emergency pests. Farm biosecurity involves a set of management practices and activities that are carried out on-farm to protect a property from the entry and spread of pests. Key elements of plant biosecurity at a farm scale should include:

- Prevention: use simple biosecurity measures to protect the industry by keeping crops pest free and preventing movement of pests between regions.

- Awareness: make sure you, your farm workers and contractors are familiar with local and common pests and the most important strawberry pest threats (emergency/notifiable pests) for your region so that any new pests can be identified.
- Training: conduct biosecurity training sessions on your farm, during induction and refresher training; and use photos or posters to explain hygiene practices for workers, equipment and vehicles.
- Know your sources: ensure all propagation material (runners) and farm inputs are fully tested and pest free. Keep records (batch numbers, source) and retain a sample of your farm inputs. Be especially careful with second hand packaging, bins and machinery movements.
- Keep it clean: practicing good sanitation and hygiene will help prevent the entry and movement of pests onto your property. Workers, visitors and even you can spread pests, so make sure to clean dirt and plant material from any footwear, equipment or vehicles at point of



## Pest management

entry to your farm. Restrict the movement of people, vehicles and machinery on your farm.

- Use signage: inform visitors and contractors and remind staff of your biosecurity and hygiene measures and identify any problem areas on your farm to prevent weeds or pests from spreading.
- Check crops: monitor your crops frequently. Knowing the usual crop appearance will help you recognise new or unusual pests or plant symptoms. Keep written and photographic records of all unusual

observations. Constant vigilance is vital for early detection of any exotic or new endemic pests.

- Abide by the law: support and be aware of laws and regulations established to protect the strawberry industry and other horticultural industries in your region, and
- Familiarise yourself with the Strawberry Industry Biosecurity Plan. The Strawberry Industry Biosecurity Plan is available from the Plant Health Australia website at [www.planthealthaustralia.com.au](http://www.planthealthaustralia.com.au)

## Pest management

To find out more about how you can protect your farm, go to the farm biosecurity website at [www.farmbiosecurity.com.au](http://www.farmbiosecurity.com.au).

### Integrated crop protection

Cultivated crops are exposed to pressures from pests (insects, weeds and diseases) and the general or manipulated environment. Pest pressures can be reduced by using an integrated approach to crop protection. Integrated Crop Protection (ICP), also referred to as Integrated Pest Management (IPM), focuses on the whole system including pests, the crops, the environment and soil (or growing media) health.

Good decision-making on crop protection requires consideration of the:

- Crop
- Potential and present pests (weeds, insects and diseases)
- Beneficial organisms (such as *Orius*,

*Persimilis* and *Cucumeris*)

- Growing environment and wider environment
- Farm workers
- Market requirements

The ICP approach provides practical alternatives to conventional pest control, this means proactive monitoring and management of your crop rather than reliance on synthetic pesticide application on a calendar basis. This section outlines the:

- Key ICP principles
- Components of ICP
- Specific ICP steps
- General management tools and options in ICP.

For specific information on managing soilborne diseases, foliar diseases, chewing/biting insects, sucking insects (which sometimes carry and transmit viruses), and some stories of producers who have successfully applied ICP, see the fact sheets available on the good practice page of the Strawberry Innovation website.





# Pest management

## Why adopt ICP?

Producers have reported that adopting ICP strategies has allowed them to:

- Regain control over chemical-resistant pests
- Minimise worker and environmental impacts
- Minimise synthetic pesticide use and residues
- Satisfy consumers and the marketplace
- Reduce costs
- Meet quality assurance requirements

Implementation of the basic principles of ICP (below) with the assistance of ICP experts is your best starting point. Embedding the principles into your practices, will maximise the benefits. Examples of where ICP has helped manage pest populations in strawberries are discussed in the factsheets on managing soilborne disease, foliar disease, chewing/biting pests and sucking pests available on the good practice page of the Strawberry Innovation website.

## What is 'integration'?

Integration means combining two or more different management practices that are compatible, i.e. practices that work well together, not against each other. For example, an effective ICP system might include cultural measures like changing varieties or planting times, the release of beneficial organisms and the use of 'soft' pesticides. The aim is not zero pests, but rather sustainable pest management.

The most appropriate and effective crop protection programs are developed by teams that include producers, researchers and/or consultants experienced in ICP. They have specific knowledge and understanding of the stages of crop growth, key threats, impact of environmental conditions, and options available for protecting a crop from adverse events and organisms.



IMAGE 4-2: CHILEAN PREDATORY MITE PHYTOSEIULUS PERSIMILIS

# Pest management

Producers and their advisers recognise prevention efforts are preferable to eradication attempts, and that biological balance is more sustainable than a 'zero pest' environment. Take steps that allow specifically-targeted decisions and actions.

ICP programs are unique to each season, each crop, and each region. You and your advisers will become skilled in evaluating the relative importance of pest variations year-to-year on your property, and what

strategic adjustments are required to ensure continued improvement and timely responses.

## The key components of an ICP Program

**Knowledge** – Learn about the key pests, their enemies and how they enter, grow, establish, spread, survive and affect your crop, in your growing environment.

### KEY ICP PRINCIPLES

- Gain confidence in ICP through education, observation and action. Seek trusted, qualified advisers to get you started.
- Be proactive – aim for prevention rather than eradication. Don't wait for a crisis in pest control before you act.
- Access training in ICP principles for yourself and your staff.
- Commit time, effort and resources to ICP implementation. Use available resources – consultants, researchers, books, factsheets, internet.
- Know the history and nature of the pests in the seedling nursery and on your farm.
- Pests have natural enemies. Preserve and increase them. If they are available from an insectary, consider releasing reared natural enemies (known as 'beneficials').
- Make sanitation an on-farm priority.
- Monitor your crops and growing environment often.
- Record crop and pest observations eg. populations of pests and beneficials, susceptible varieties and stages of growth, weather events.
- Review treatment effectiveness: chemical coverage, performance, and resistance development.
- Understand why the 'integrated' approach increases your chance for success.



# Pest management

Prevention and minimisation – Learn about the other factors that affect the relationship of the pests and the crop planting time and location, variety planted, crop rotations, and irrigation and nutrient management. Make decisions that reduce the potential impact of the pest, while promoting the crop's chance to avoid, tolerate or resist it, and economic levels of damage.

Monitor and Observe – Look at your crop often and learn how, when and where to look for signs of the pest, symptoms of disease, the pest itself, and its natural enemies.

Respond – Keep records of what you observe and learn how to interpret them. Know the relevant response options (including synthetic and soft pesticide treatments), the treatment thresholds (i.e. conditions or potential damage levels that indicate a treatment is required) and the critical timing of the responses.

## Some key steps along your ICP pathway

Plant biosecurity is a set of measures designed to protect a crop from emergency pests. Farm biosecurity involves a set of management practices.

### Knowledge:

- Know your suppliers (runners) and keep good records.
- Know your pests – have their identity confirmed, know their biology and behaviour, how they compete and their competitors, and the conditions conducive to their presence and spread.
- Understand and practise high-level site sanitation and worker and equipment hygiene.
- Know the effect of registered pesticides (chemicals used to control pests, including synthetic or biologically-derived biopesticides) on natural enemies and beneficials.
- Know the block history – previous crops, soil health, and the impact of pests, nematodes, weeds and diseases.

### Prevention:

- Conduct pre-plant soil tests for soilborne pests, when appropriate.
- Only plant suitable material.
- Recognise 'normal' and 'abnormal' organisms, plant appearance, and responses to treatments.

# Pest management

- Minimise plant stress – optimise soil preparation and soil health, water and nutrient applications.
- Avoid mechanical damage to plants.
- Remove plant debris, non-commercial vegetation and weeds that harbour pests.

### Monitor and observe:

- Understand the weather forecasts of relevance.
- Monitor your crops and use experienced crop scouts to follow populations of pests and beneficials, and to identify and assess severity of diseases.
- Use sticky traps, pheromone traps, leaf wetness sensors, disease prediction models, and insect development models to assist in collecting data.

### Respond:

- Set your goals! Plan and define your measures of 'success' and 'failure'.
- Consider planting schedule and crop sequence changes.
- Protect the environment – maintain and protect soil and water resources.

- Use pesticides only as needed. Do not rely solely on them.

### What management options are available?

Cultural, physical or mechanical options – These options assist crops in avoiding, resisting or delaying interaction with the pest. They include site selection, fallow periods, crop-free periods on a regional level, planting date changes that consider pest flights and/or weather, minimising old/new crop overlaps, resistant varieties, crop rotation, roging (removal of sick/dying plants), insect screens, positive greenhouse pressure, removal of pest habitats, establishment of refuges for beneficials, and/or restricted people movement.

Chemical options – These options involve using natural, biological, 'soft' or narrow-spectrum chemicals to alter pest behaviour, to attract pests for early warning and predictive purposes, to reduce the presence or impact of pests, and/or to change the attractiveness of the host crop. 'Chemical' options suited to ICP include pheromones, *Bacillus thuringiensis* (Bt) and biofumigation.



## Pest management

Variety options - Resistant varieties limit the impact of pests and should be used whenever available and horticulturally acceptable.

To identify chemical options available for managing pests in strawberries, refer to the Strawberry Chemical Guide, available on the good practice page of the Strawberry Innovation website.

Biological options - These options rely on natural enemies or introduced organisms that limit the impact of a pest. Introduction of biological control agents also require the integration of crop management practices that boost or extend the habitats and populations of beneficials, parasitoids, antagonists and predators. Beneficials include all predatory insects, mites and spiders; parasitic wasps, nematodes and flies; and fungi or bacteria that attack pests or outcompete them for potential infection sites. Commonly seen beneficials include: ladybird

## Pest management

beetles, *Orius* (a predator of thrips), *Eretmocerus* (a wasp that parasitises whiteflies), *Persimilis* predatory mites (which attack spider mites such as red spider mite or two spotted mite), and brown lacewings. These beneficials all play a significant role in ICP. There are a number of commercial suppliers of biological control agents and providers of ICP advice for strawberry pests.

For further information on integrated crop protection please visit the good practice page of the Strawberry Innovation website.

These include (but are not limited to):

- Bugs for bugs  
[www.bugsforbugs.com.au](http://www.bugsforbugs.com.au)
- Biological Services  
[www.biologicalservices.com.au](http://www.biologicalservices.com.au)
- IPM Technologies  
[www.ipmtechnologies.com.au](http://www.ipmtechnologies.com.au)





# Pest management

## PEST MANAGEMENT CHECKLIST

The following checklist provides a quick, easy way to assess how well you are implementing best practice pest management and will help to identify any actions to improve your pest management.

**TABLE 4-1: PEST MANAGEMENT CHECKLIST**

| RECOMMENDED PRACTICES   | YES | NO | N/A | ACTION REQUIRED IN THE NEXT 12 MONTHS |
|---|-----|----|-----|---------------------------------------|
| <b>Do you:</b>  |     |    |     |                                       |
| Understand and recognise the major pests (insects, weeds and diseases) that affect strawberry crops?  |     |    |     |                                       |
| Ensure appropriate sanitation and hygiene practices occur on your property and when moving plant and equipment?                                 |     |    |     |                                       |
| Monitor for pests and beneficial organisms on a regular basis? Or use a consultant to monitor and advise for you?                               |     |    |     |                                       |
| Manage pests in accordance with legal requirements?   |     |    |     |                                       |
| Use an ICP program to manage your farm, crops, native vegetation and other pest hosts to minimise the risk of pests establishing and spreading? |     |    |     |                                       |

# Pest management

## HELPFUL RESOURCES

Strawberry problem solver and bug identifier – Queensland Department of Primary Industries and Fisheries

Common insect pests of strawberries (Primefact 891 NSW Department of Primary Industries – <https://static1.squarespace.com/static/57285e9e59827e6e7a1467f2/t/59b891a764b05fc68d92be42/1505268136670/Common-insect-pests-of-strawberries.pdf>)

Keep It CLEAN – Reducing costs and losses in the management of pests and diseases in the greenhouse. Download from the following link: <http://www.dpi.nsw.gov.au/agriculture/horticulture/greenhouse/pest-disease/general/preventing/keep-it-clean>

Controlling Invertebrate Pests in Agriculture. 2012. Book by Paul Horne and Jessica Page of IPM Technologies Pty Ltd. Order from CSIRO Publishing via the following link: <http://www.publish.csiro.au/pid/6734.htm>

## REFERENCES

Crop Life Australia <https://www.croplife.org.au>

Mega Pest Factsheets developed for InnoVeg by Scholefield Robinson Horticultural Services Pty Ltd and Sandra McDougall (NSW DPI).

Plant Biosecurity CRC <http://www.pbcrc.com.au>

## PHOTO CREDITS

Image 3-1: Photo courtesy of National Pork Board and the Pork Checkoff. Des Moines, IA USA

Image 3-2: Photo courtesy of Strawberry problem solver and bug identifier. Queensland Department of Primary Industries and Fisheries

Image 3-3: Photo courtesy of Dr Kristen Stirling. RMCG

Image 3-4: Photo courtesy of Dr Kristen Stirling. RMCG

Image 3-5: Photo courtesy of Strawberry problem solver and bug identifier. Queensland Department of Primary Industries and Fisheries

Image 3-6: Photo courtesy of Strawberry problem solver and bug identifier. Queensland Department of Primary Industries and Fisheries.



**ABOVE: PREDATORY LADYBIRD BEETLE *HARMONIA CONFORMIS* FEEDING ON APHIDS**

**LEFT: BROWN LACEWING *MICROMUS TASMANIAE***



# Postharvest handling of strawberries

## OBJECTIVE

- Maintain fruit quality from farm gate to consumer
- Maximise fruit shelf life

## WHY IS IT IMPORTANT?

Strawberries are highly perishable fruit, requiring careful handling and strict adherence to appropriate postharvest management practices to maintain optimal fruit quality after harvest. For maximum shelf life, strawberries require rapid removal of field heat, low temperature storage (0 to 1°C) and maintenance of cool storage during transport and distribution.

With optimal postharvest care and the appropriate cultivar, strawberries can have a shelf life of 7 to 10 days. To realise this potential, attention must be given to all aspects of product handling, packaging, and postharvest temperature and relative humidity management.

Good postharvest temperature management is the single most important factor influencing strawberry shelf and fruit quality.

It's important to realise that poor postharvest handling at any stage will reduce quality and shelf life. You cannot undo bad practice.

This chapter on strawberry postharvest handling has been developed for strawberry growers in Australia, to provide comprehensive technical information and recommendations on all aspects of postharvest care of strawberries.

# Postharvest handling of strawberries

## RECOMMENDED PRACTICES

### In the field

#### *Agronomic practices*

Rain events are associated with a higher level of fruit damage either due to fungal infection or snail and slug damage.

Growers who produce under low cloches should install the cloches so that hoops are away from the edges of the raised beds. This means when the covers are raised and lowered the fruit on the outside rows stays dry instead of being subject to drips from the covers. Many growers are moving to high tunnels for this reason.

Other management practices including over-irrigation and over-fertilising can adversely impact fruit quality. Trials in Western Australia showed that levels of nitrogen in excess of 450kg/ha on sandy soils were attributed to poor fruit quality<sup>1</sup>

#### *Hygiene*

Good field hygiene impacts product quality in the field and continues through to the packing shed. Diseased or damaged fruit should not be left in the field, either on the ground between rows or in a heap elsewhere on the property. Reject fruit in the field serves as a source of inoculum, enabling the spread of disease onto both plants and

<sup>1</sup> Hulcup & Phillips (2000) Nitrogen nutrition of strawberries in a temperate production system. DAFWA.





## Postharvest handling of strawberries

fruit. Overripe fruit left in the field can provide a breeding ground and habitat for unwanted pests such as fruit fly and stable fly. To help prevent the spread of disease from infected or rotting fruits to healthy fruit, pickers should use a separate container to store discarded fruit.

Ideally, workers removing damaged and diseased fruit should be different from those picking fruit for sale.

### Harvesting

Strawberries should be harvested in the coolest part of the day where possible. Fruit should be dry to touch, as wet fruit is prone to develop postharvest fungal problems.

Growers in Australia use a variety of cultivation methods and produce at different times of the year. Those growing in rainy periods and without protected covers need to be particularly vigilant.

Strawberry fruit intended for export should not be picked when the pulp temperature exceeds 25° C. On hot days pulp temperatures may reach up to 30-

35°C, as a rule of thumb however, pulp temperature is normally a few degrees less than ambient air temperature.

Warm fruit bruises more easily than cool fruit, as well as requiring more energy and cooling capacity to remove the field heat after picking.

Some strawberry varieties are particularly susceptible to bruising and must be picked at an earlier stage to avoid damage especially if being shipped.

Harvest frequency depends on many factors including the time of year and may be daily in warm weather. Early in the season when volumes are low it may be once or twice a week. Every three or four days is common in winter growing areas.

Strawberry fruit are very delicate and easily damaged. Since the harvest crew is responsible for grading, packing, and gentle handling, their training is critical to packing a quality product.

Trials in Western Australia evaluated the effect of normal commercial handling versus careful handling on the quality and shelf life of strawberries. Figure 5-1

## Postharvest handling of strawberries

shows the difference in fruit quality one week after picking.<sup>2</sup>

Bruising as a result of commercial handling while picking and packing fruit is second to incorrect temperature control as the major cause of poor quality fruit in the market.

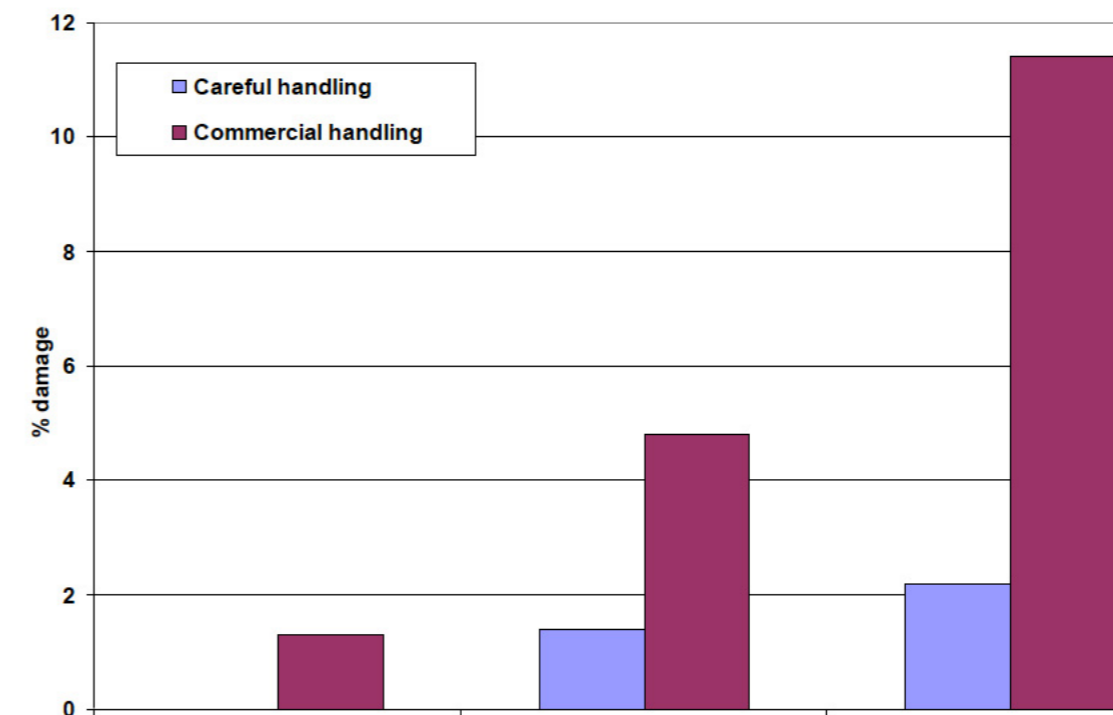
Growers face major limitations in this regard due to their dependence on regard due to theirbut there is still

scope for improving fruit handling either through better training and education or by giving employees more ownership of the problem – for example, by rewarding better handling practices through a different system of remuneration.

### Maturity

Strawberries are considered as non-climacteric fruit and in general do not ripen after picking.

<sup>2</sup> Bhat & Reid (2010) Increasing the shelf-life of Australian strawberries. DAFWA.

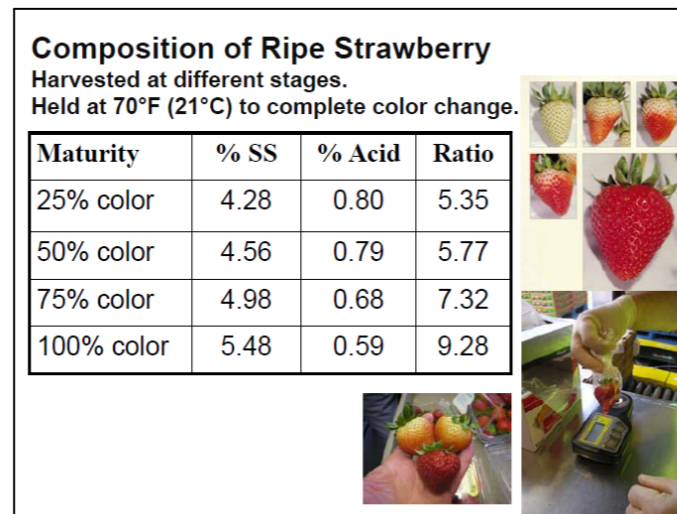


**FIGURE 5-1: COMPARISON OF COMMERCIALY PICKED AND CAREFULLY PICKED STRAWBERRIES AFTER ONE WEEK OF STORAGE (BHAT AND REID 2010)**

## Postharvest handling of strawberries

However, some varieties can be harvested at 3/4 colour and will ripen sufficiently postharvest.

While maturity is commonly assessed by surface colour, trials as illustrated in Figure 5-2 have shown that colour is not always a good indication of flavour (favourable sugar/acid levels). Flavour varies between varieties and is also affected by a range of factors including sunshine hours, crop load and fertiliser program. Not all of these are within the producer's control.



**FIGURE 5-2: RIPENING STAGES AND MATURITY INDICES OF STRAWBERRIES. CLOCKWISE FROM TOP LEFT: 0%, 25%, 50%, 75% AND 100%.**

CREDIT: MARITA CANTWELL UC DAVIS



**IMAGE 5-4: EXAMPLES OF PICKING TROLLEYS USED IN WESTERN AUSTRALIA**

## Postharvest handling of strawberries



**IMAGE 5-3: COVERED WAGON USED FOR TRANSFER OF HARVESTED STRAWBERRIES FROM THE FIELD TO SHED**

The best time to pick fruit may be based on external factors such as market preference and shipping time, consequently fruit are not always picked with full colour. Each variety will have its unique characteristics such as a white shoulder even when fully ripe. The depth and speed of colour changes will also vary with variety.

### *Picking aids*

Most growers use some form of picking cart as a harvest aid. The carts are designed to be pushed in front of the picker and each holds up to about 20 trays of fruit.

Picking trolleys have a range of designs and many growers design their own to suit their particular planting configuration using locally and readily available materials as illustrated in Image 5-2.

Picking trolleys allow both hands of the picker to be used for harvesting, enabling greater worker efficiency. Fruit is subject to less bruising which ultimately assists shelf life.

As picking trolleys are filled, the trays of fruit are transferred onto racks for transfer to the packing shed as illustrated in Image 5-3.



## Postharvest handling of strawberries

Fruit should not be left in the sun. Trials using hessian to shade racks proved counterproductive due to reduced air flow. Fruit should be transferred to the packing shed as quickly as possible. It may be useful to impose time limits for the period that picked fruit is left in the field.

### Field packing

If field packing, pickers should be properly trained to pack and grade the fruit directly into the final retail container at the time of harvest. The container must be large enough to easily hold the required weight of fruit without squashing or damaging it.

Over-ripe, under-ripe, diseased, or insect damaged fruit must not be packed. Grading fruit directly into the retail container at harvest time reduces the number of times fruit is handled, minimising bruising, improving quality, and minimising costs.

Monitoring the harvesters and careful field supervision is critical to the success of the operation and the quality of the fruit. Picker performance can be extremely variable and workers may need to be reminded to handle the fruit with care. Pickers should not squeeze the berries and should place them gently in the market container.



**IMAGE 5-4: EXAMPLE OF IN-FIELD PACKING AND QUALITY ASSURANCE IN TASMANIA**

All fruit should pass through a final check to ensure correct weight and grading as demonstrated in Image 5-5. Where necessary, individual, poor quality fruit in some of the containers may have to be removed and replaced with good quality fruit. However, if field workers are properly trained in field packing, this should be minimal. Cartons should be kept in the shade and protected from the wind. An efficient system should be developed for inspecting the cartons prior to frequent delivery of the cartons to the cooler/cold storage facility.

## Postharvest handling of strawberries

### Transfer to shed

To maintain optimum quality and marketable life, fruit should be placed in a coolroom within one hour (or less) of picking.

The receiving area should be covered to shade the fruit from direct sunlight and protect against rain. The flow of product can be made more efficient by using conveyors, pallets, and hand pallet-jacks for moving the cartons from one area of the cooler/cold storage facility to another. If individual containers were not weighed in the field packing/inspection station, they will need to be check-weighed, prior to cooling.

### In the shed

#### Quality requirements

Australia has no legislated standards for strawberries however quality standards are often set by the buyer. Quality criteria may cover aspects including:

- Appearance (colour, size, shape, freedom from defects and disease)
- Firmness
- Flavour (soluble solids, titratable acidity and flavour volatiles)
- Nutritional value (Vitamin C)
- Sugar content (does not increase after harvest). For acceptable flavour, a minimum soluble solids content of 7% and a maximum titratable acidity of 0.8% are recommended (Kader 1999).





## Postharvest handling of strawberries



Minimum requirements may require that the fruit be:

- Intact and undamaged
- Sound (produce affected by rotting or deterioration such as to make it unfit for consumption is excluded)
- Clean (practically free of any visible foreign matter)
- Fresh in appearance but not washed
- Practically free from pests or pest damage
- With the calyx and the calyx and stalk (if present) fresh and green

- Free of abnormal external moisture
- Free of any foreign smell and/or taste
- Sufficiently developed and displaying satisfactory ripeness.

The development and the condition must be such as to enable them:

- To withstand transportation and handling, and
- To arrive in satisfactory condition at the place of destination.

## Postharvest handling of strawberries

### *Packaging*

Strawberries are highly sensitive to compression and vibration damage and very susceptible to water loss, as a result packaging needs to provide physical protection to the fruit.

Strawberries are packed into a variety of container types and sizes. Materials used include polyethylene terephthalate (PET), recycled polyethylene terephthalate (RPET), polypropylene (PP), or PVC (poly vinyl chloride). Clamshells with a clip-on lid are most common, but heat seal plastic is also used. Plastic film wrap is less common. Net volumes are usually either 250 or 500g, but the actual punnet size may vary. The bottom of the clamshell (more usually 500g sizes) may be padded with bubble wrap to minimize vibrational damages. Larger punnets are used by some grower. They are easier to pack as staff don't need to be trained and less bruising occurs but logistically can be less efficient.

Clamshells are always vented to allow air circulation. This facilitates air movement and helps prevent condensation within the punnet which promotes postharvest

diseases such as botrytis. The vents also allow effective forced air cooling.

Punnets (primary packaging) are placed in either cardboard cartons or returnable plastic trays and palletised for transport. Most trays hold 12 - 15 punnets.

Palletised strawberry cartons require some type of strapping or corner strips to stabilize the pallet load and prevent load shift in transit. It is very important to avoid overloading the pallet. Cartons should never extend beyond the edge of the pallet, because this will cause the cartons at the base of the stack to collapse, and possibly lead to the collapse of all cartons.

### *Cooling and refrigeration*

Strawberries are extremely perishable. Begin cooling within one hour of harvest to avoid loss of quality and reduction in the amount of marketable fruit.

Temperature management by cooling is the single most important factor in minimizing strawberry deterioration and maximizing postharvest life.



## Postharvest handling of strawberries

The incidence and severity of decay, mainly caused by *Botrytis* and *Rhizopus*, can be reduced by around 25% if the fruit is properly pre-cooled. Cooling extends shelf life by reducing:

- respiration rates
- water loss
- ethylene production
- sensitivity to ethylene
- microbial development (spoilage).

Fruit which is not cooled after harvest deteriorates rapidly and may only have a shelf life of 1-3 days. A delay of 4 hours before refrigeration will result in one-third of fruit becoming unmarketable after seven days (Figure 5-3).

Once fruit is cooled it should be kept cool because cycles of warming and cooling produce condensation on the fruit leading to *Botrytis* and other storage diseases. Any break in the cold chain (0 to 1° C) will decrease shelf life significantly.

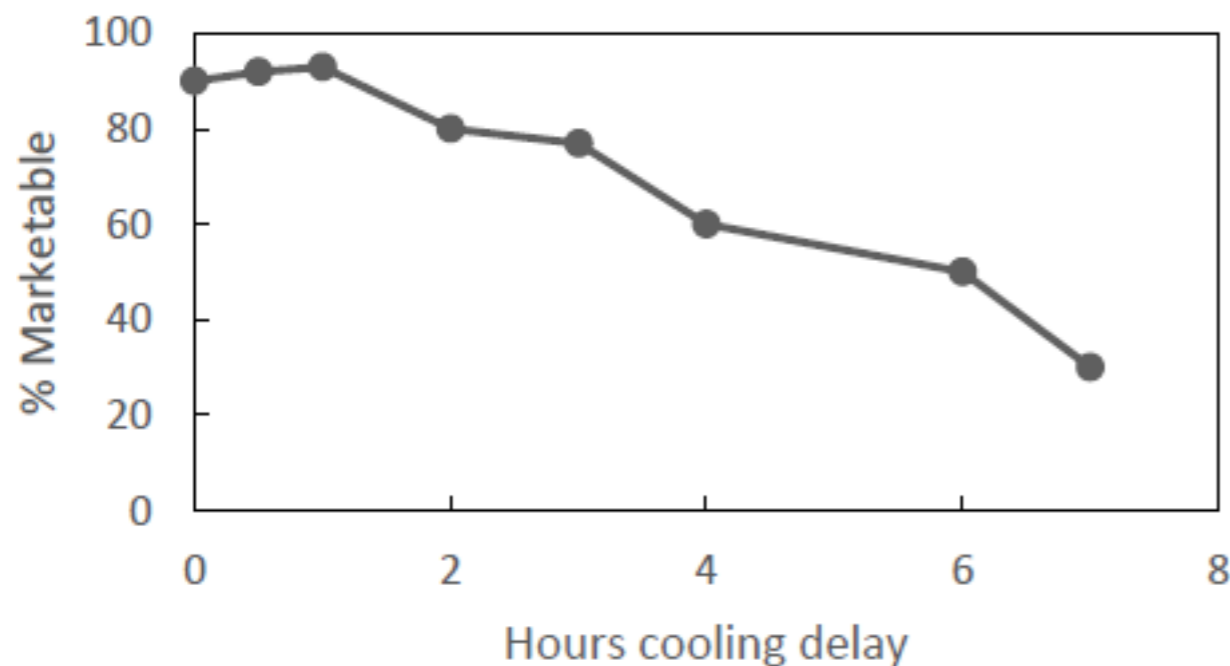


FIGURE 5-3: EFFECT ON COOLING DELAY AFTER HARVEST ON THE MARKETABILITY OF STRAWBERRIES (REDRAWN FROM MITCHAM ET AL 1996)

## Postharvest handling of strawberries

The packing shed should be designed for a smooth and rapid flow of product from the field to the grading and packing area, into the forced-air cooler and then to the coolroom at 0 to 1°C.

Packing sheds can be insulated and cooled. Evaporative cooling is useful, particularly when ambient humidity is low. Packing and grading areas may be air-conditioned or even refrigerated to about 15°C.

### Refrigerated storage

Strawberries lose water rapidly after harvest. To prevent fruit shrivelling and wilting or dehydration of the green calyx it is important to maintain a high relative humidity (RH) during postharvest handling. The optimum RH for strawberries is 90 to 98 %.

Strawberry fruit can be stored for up to 7 days at 0 °C depending on disease pressure. Strawberry flesh freezes at between 0.6°C and -0.8°C, depending on total soluble solids content.

Many strawberry growers do not use humidified coolrooms. Their reasoning is that fruit is highly perishable and never

held long enough for humidification to make a difference.

There are various way of maintaining a high RH during storage. They range from wetting the floor, or having open containers filled with water. Both are inexact methods and not advisable from a food safety point of view. A better method is to use an automatically controlled fogging or humidification system.

### Ethylene Production and Sensitivity

Strawberries produce very low amounts of ethylene (<0.1 µL kg<sup>-1</sup> h<sup>-1</sup> at 20°C). They do not respond to ethylene. However, the removal of ethylene from storage air may reduce disease development.

### Transport

Cartons should be removed from the coolroom and loaded into a pre-cooled refrigerated truck (near 0°C) without breaking the cold chain. Ideally, strawberries should be transported to the market destination the same day they are picked.

## Postharvest handling of strawberries



**IMAGE 5-7: COMPARISON OF NON-INSULATED (LEFT) AND INSULATED (RIGHT) BERRIES AS RECEIVED IN SYDNEY**

Cooled strawberries that are allowed to re-warm will have condensation on the inner surface of the plastic container and the fruit. This will increase their susceptibility to fungal decay and reduce transit are essential to minimize post-harvest decay as highlighted in the comparison quality photos in Image 5-7.

### *Temperature logging in transit*

Maintenance of the cold chain and temperature monitoring should be an integral part of quality control. fruit shelf life. Even a small amount of botrytis can spread rapidly from one infected fruit in the container to all adjacent healthy fruit throughout an entire carton. Low temperatures during Temperature records can be used to support any potential claims on arrival or due to delivery delays. Temperature recorders

are usually placed 1.5 m above the floor (for ease of checking) about two-thirds the way to the back of the vehicle. They should not be placed in a cold area such as near the air discharge of the refrigeration unit.

### *Thermal blankets*

Another method used to maintain the cold chain during transit is to over-wrap the stack of cartons on the pallet with a foil laminated thermal blanket (Image 5-8). The external foil surface of the thermal blanket reflects ambient heat while the air pockets inside the insulation material keep out heat. Thermal blankets can maintain a temperature of 3°C within the cartons for up to 36 hours.

## Postharvest handling of strawberries

### *Thermal sea transportation*

Trial overseas shipments of pre-cooled and insulated fruit consignments from Perth to Singapore have been encouraging. Fruit arrived in very good quality, even after 12 days of sea transit, and compared very favourably with inappropriately handled fruit that arrived within a day by air at Freshmart Singapore from Perth.

### **Postharvest disinfestation treatments**

Methyl bromide fumigation is routinely used for strawberries shipped to Tasmania or exported to certain overseas countries such as Thailand.

CA-04 is the quarantine standard for fumigation with methyl bromide and is available from the interstate quarantine website:

<http://www.interstatequarantine.org.au>

Effective fumigation in an approved fumigation chamber takes two hours and has a time versus temperature relationship as shown in Table 5-1.



**IMAGE 5-8: PALLET WITH FOIL LAMINATED THERMAL BLANKET**

Methyl bromide fumigation has a detrimental effect on strawberry quality and shelf life. Berries are softer and darker in colour than unfumigated berries and the calyx browns prematurely. There is an increased incidence of leak and decay. This may be partly due to having to delay fruit cooling prior to fumigation. Fruit is not generally cooled and then warmed prior to fumigation as this promotes condensation on the fruit surface. Wet fruit is subject to increased damage from fumigation.



## Postharvest handling of strawberries

**TABLE 5-1: TIME AND TEMPERATURE RELATIONSHIP OF EFFECTIVE FUMIGATION**

| Temp °C | Rate g/m <sup>3</sup> |
|---------|-----------------------|
| 10-10.9 | 56                    |
| 11-15.9 | 48                    |
| 16-20.9 | 40                    |
| 21+     | 32                    |

### *Irradiation*

Queensland is the only state with a facility large enough to treat commercial quantities of fruit however irradiation is not yet permitted for strawberries in Australia as a postharvest treatment.

Irradiation is far superior to methyl bromide for controlling postharvest rots however irradiated fruit also softens noticeably after treatment. The response of strawberries to irradiation varies markedly with cultivar with some cultivars able to withstand higher rates of irradiation than others without a decline in quality.

### **Postharvest diseases and disorders**

Information on postharvest diseases and disorders is available on the good practice page of the Strawberry Innovation website.

## Postharvest handling of strawberries

### HELPFUL RESOURCES

USDA ARS Agriculture Handbook Number 66. Revised February 2016. The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks

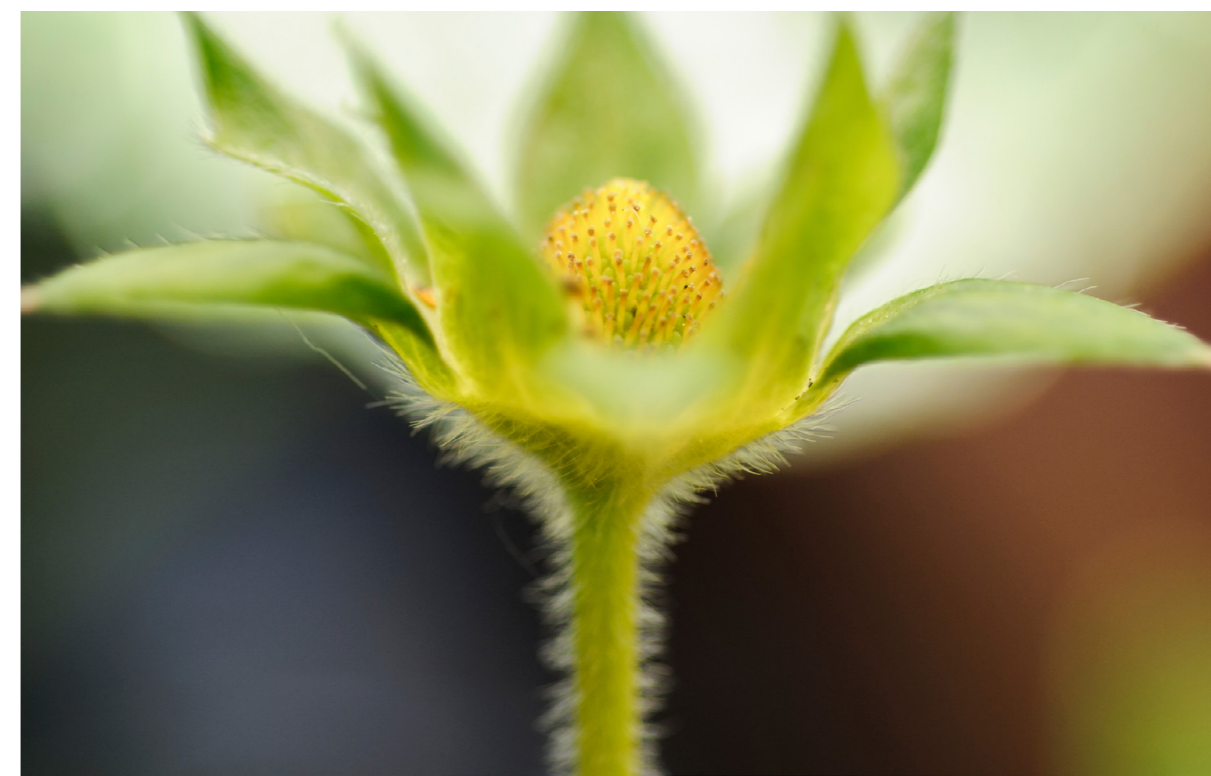
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## Postharvest handling of strawberries

### CHECKLIST

The following checklist provides a quick, easy and actionable way to assess how well you are aligning to the recommended best practice.

**TABLE 5-2: POSTHARVEST HANDLING OF STRAWBERRIES CHECKLIST**

| RECOMMENDED PRACTICES  | YES | NO | N/A | ACTION REQUIRED IN THE NEXT 12 MONTHS |
|--|-----|----|-----|---------------------------------------|
| Is the fruit being picked out of the withholding period for pesticides?                    |     |    |     |                                       |
| Are pickers adequately trained to pick fruit of the appropriate stage and quality?         |     |    |     |                                       |
| Is the time between fruit being picked and transported to cool storage less than one hour? |     |    |     |                                       |
| Are packers trained to handle fruit with care and inspect for defects and foreign bodies?  |     |    |     |                                       |
| Is the packing shed set up to enable efficient product flow?                               |     |    |     |                                       |
| Are temperature fluctuations in the coolroom and transport kept to an absolute minimum?    |     |    |     |                                       |

## Postharvest handling of strawberries

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<https://content.ces.ncsu.edu/forced-air-cooling>

<http://www.trj-inc.com/forcedAirCool.html>

<http://www.postharvest.net.au/postharvest-fundamentals/cooling-and-storage/cool-rooms/>

**This chapter on postharvest handling of strawberries has been developed by Aileen Reid, Strawberry Industry Development Officer for Western Australia.**

### STRAWBERRY FAST FACTS

For best quality fruit:

- Remove field heat as soon as possible
- Do not allow fruit to cycle between warm and cool temperatures.
- Keep fruit as close to 0°C as possible.









**STRAWBERRY INNOVATION**

Australian Strawberry Good Practice Guide

2019