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Production of premium waxflowers

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Production of premium waxflowers

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New Crop Variety Introduction and Propagation

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Information on procedures, chemicals and rates listed are not recommendations for waxflower and can only be used as a guide. Growers need to check registrations and test each application for their particular situation.

Acknowledgments

The original waxflower manual—Miscellaneous Publication 21/2003 *Managing waxflower for improved quality and profit*—has been extensively revised by Kevin Seaton, Project Manager, Innovative Plant Products and the review has been coordinated by Nikki Poulish, Development Officer, Innovative Plant Products, DAFWA and contributions to the original publication are acknowledged (Kevin Seaton, Digby Growns, Aileen Reid, Gerry Parlevliet, Peter Wood, Bill Woods, Tim Calder and Kim Burke from DAFWA, as well as the many other contributions of original material, photographs, suggestions and comments from other industry members).

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Flowering stems of Bridal Pearlȸ

Index

1. Production of waxflowers for the cut flower trade

Production essentials

Know your flower marketing options.

Quality control throughout the supply chain is critical—this means having:

- appropriate variety selection
- effective irrigation and nutrition
- insect- and disease-free plants
- optimal time and timing of picking
- correct postharvest handling (harvesting, temperature control, anti-ethylene treatments)
- professional presentation of final product.

Set the scale of your enterprise.

Obtain relevant licences (planning approval, native flora commercial producer's licence, water allocations etc).

Crop monitoring can save you money and lift crop quality:

- soil and tissue testing
- tensiometers for optimal irrigation scheduling.

Business planning, benchmarking and record keeping will help you keep track of production and quality.

Flex your business to market conditions.

Successful cut flower production relies on the delivery of a premium quality product. It is essential for the waxflower industry to work together to implement the quality management techniques outlined in this bulletin (see Figure 1.1).

The cut flower supply chain

There are often many stages between the grower and the consumer—wholesalers, exporters, auctioneers, florists, supermarket buyers and the local shop manager (Figure 1.1).

Each part of the chain has specific requirements, and growers may deal with one or many parts of the chain.

Ultimately, the market is the consumer and it is important that waxflowers create appeal in the retail outlet or catalogue.

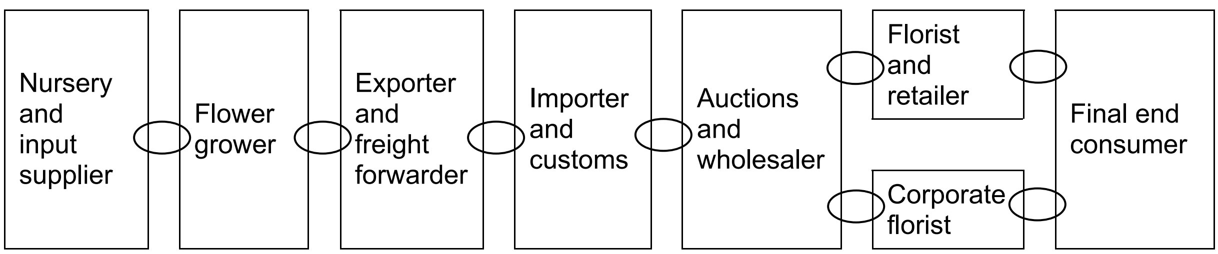
Your marketing options

When deciding on your marketing options, there are two broad categories—domestic and export markets.

Export markets differ from domestic markets and have different requirements.

The high cost of transport to export destinations means it is only viable to send high value products that can attract good prices.

Domestically, high value products are still preferred, but there is a place for lower cost bulk flowers.



= *Intermediaries provide transport, aggregation, financing and other services.*

Figure 1.1. Flower supply chain

Competing on a global market

The cut flower trade is a highly competitive global market. Waxflowers are grown around the world—often in countries with lower cost structures or closer proximity to our main markets.

Western Australian producers can only compete if their product stands out from the crowd in terms of quality, presentation and uniqueness, however, it still has to represent good value for money so:

- plant varieties that are going to achieve good returns
- use recommended production techniques to ensure good stem length and no damage from insects and diseases
- schedule flowering to meet market requirements
- pick flowers at the correct stage
- place harvested flowers in water immediately to hold their temperature and moisture levels
- keep harvested flowers in the shade or in a cool insulated vehicle and get them to the packing shed fast
- treat flowers postharvest to ensure they are insect-free and have sufficient vase life
- grade uniform lines—colour, size and shape of flowers, stem length and/or bunch weight
- pack flowers in the right size sleeve/carton; cool rapidly to 2 °C and transport in refrigerated trucks—holding temperature around 2 °C
- transfer flowers immediately to the wholesaler/exporter/florist's coolroom
- distribute flowers to florists/retail outlets/consumers in insulated or refrigerated trucks or vans
- ensure the exporter transfers flowers from the warehouse to the overseas consumer quickly and directly while maintaining cool temperatures.

Essentials of producing premium quality waxflowers

Consumers want value for money, colour, freshness, freedom from disease and long vase life. They are always after new types, so uniqueness is also important. Many of these things are under the control of the grower.

Following best-bet management practices determines the health, productivity and quality of flowers.

Increasing efficiency and productivity can also impact on quality. A 30 per cent increase in stem yield can be achieved by refining fertiliser and irrigation management.

***Figure 1.2. Premium quality Pearlflower variety WX 56*⊕**

Quality control

Quality starts with nursery propagation of tube stock and continues through to postharvest treatment.

- Make sure plants are clean and healthy when you receive them.
- Control disease, insects and nutrients to maintain quality during production.
- Optimise management to ensure good yields, long stems and vibrant colours.
- Time of picking affects freshness and appearance of the product at the market (pick at the recommended stage of 50–80 per cent flowers open).
- Postharvest temperature control and anti-ethylene treatments ensure freshness and long vase life.
- Presentation—every bunch needs to be well presented and cartons correctly labelled with variety details.
- Quality of service—consistency of supply, documentation and dealing with complaints.

One way to guarantee quality is a quality assurance program for your enterprise that is audited by a third party such as ISO 9002 or SQF 2000. Although it may increase costs, your product will often have better market access.

How large should my enterprise be?

The scale of your enterprise will always be a balance between the capital and finance, the type of product, available labour and the ability to produce and sell on that scale.

Never plant on a scale that is too large to maintain quality at all times, from establishment through to delivery. Varieties should be selected and planted so that there are sufficient resources to harvest and process the crop even at peak production.

Crop monitoring

Plants and soil should be tested for nutrient requirements to ensure that the correct amount of fertiliser is applied. Soil and tissue testing methods can be found in Chapter 7.

Irrigation should be monitored using tensiometers or other soil moisture probes, to ensure plants are adequately supplied with water but not over-watered.

Permits, regulations and licences

Planning approval

Many shires require a development application before starting a flower enterprise. Obtain these approvals before buying land or investing additional capital.

Native vegetation clearing approval

If you wish to clear land for your enterprise, make sure you have the approval of the Commissioner of Soil and Land Conservation, giving notice of your intention to clear 90 days before doing so. Ensure you have this approval before buying new land.

You can apply for a clearing permit through the Department of Environment and Conservation (DEC—formerly CALM). Forms can be downloaded from the website at **www.dec.wa.gov.au** then under ‘Licences and permits’ select ‘clearing permits’.

Native flora commercial producer’s licence

Although you do not need a licence to grow flowers, approvals and licences are needed for various parts of the operation.

To sell native flowers, growers need a **Commercial Producer’s Licence** or **Nurseryman’s Licence**. These are also available from DEC.

From time to time, growers may also wish to harvest flowers and foliage from their remnant vegetation or Crown land to supplement supply. The plants in these areas are protected and a **Commercial Purposes Licence** is required from DEC.

These licences are available through DEC and can be downloaded from the website at **www.dec.wa.gov.au** then under 'Licences and permits' select 'flora licensing' then 'application and administration forms'.

Water allocation

A reliable, good quality water source is critical to the flower enterprise. If you are relying on water from a bore, then you may need an allocation from the Department of Water.

Applications for water allocation can be downloaded from the website at **www.water.wa.gov.au** by searching for the appropriate form under 'licensing publications and forms'.

In some areas this may require an environmental assessment to ensure there are no impacts from your flower enterprise on local rivers, wetlands, groundwater and biodiversity.

Chemicals—minor use permits

To obtain high yields and good quality flowers, nutrients need to be applied and pests and disease controlled.

Where chemicals are applied, they must be applied according to label instructions—with safety precautions and container disposal instructions followed.

While some chemicals are not registered for use on flowers or ornamentals, it is possible to apply for a minor use permit from the Australian Pesticides and Veterinary Medicines Authority (APVMA). Visit their website: **www.apvma.gov.au** or telephone (02) 6210 4748, email: Pesticide_Permits@apvma.gov.au).

Further reading

Department of Agriculture and Food, Western Australia:

- Farmnote 47/2004 *Flowers—giving the market what it wants.*
- Farmnote 45/2003 *Commercial flower growing—is it for you.*

2. Quality management of waxflowers

Quality essentials

Quality control is impacted right through the supply chain:

- variety selection
- nutrition and irrigation
- pest and disease control
- anti-ethylene treatments
- cool chain management
- export-import requirements.

Know the quality specifications required:

- flowering stage
- stem length
- bunch weight.

Develop a feedback loop along the supply chain to identify quality issues.

Successful cut flower production relies on the delivery of a premium quality product. Quality may be affected throughout the supply chain so it is essential for the waxflower industry as a whole to implement the range of quality management techniques outlined in this bulletin.

Waxflowers must be kept as fresh as possible for presentation at the point of sale. Quality management starts in the field and finishes on delivery to the consumer. The health of plants in the field, as well as postharvest conditions in the packing shed and during export, all affect flower quality.

Measurement of quality

Quality is measured by a number of factors which combine to affect the final appearance and performance.

Table 2.1 shows the quality parameters necessary to achieve a quality product.

While specifications may vary between varieties, flowers must meet the guidelines set down for their own variety. Quality parameters also ensure that the flowers meet certain standards.

Having a product of a consistent quality and meeting certain quality standards will enhance the reputation of flowers as being a quality product at markets. As a result the customer can rely on a consistent product that can be used in flower arrangements that will look and perform well.

Examples of quality standards:

1. Vase life is required to be at least 10 days. This will ensure that flowers have a sufficiently long vase life.
2. Flowers must not have any insects present when sold to quarantine-sensitive markets.

Table 2.1. Quality parameters for waxflowers

Factor	Characteristic	Measure
Yield	stem/ha	100–250
Length	cm	60+
Stem weight	bunch weight (g)	400–450
Flower density	flowers/stem	300–500
Flower distribution	compact, spreading, terminal	stated on variety description
Flowering stage	% flowers open	50–80
Vase life (flower/foliage)	days	10–15
Flower/leaf drop	%	<1%
Disease damage	blemish marks, leaf loss, shrivelling	<5%
Insect damage	chewing/sucking marks, number per stem	none

Factors affecting quality

Quality is influenced by a number of factors summarised in Figure 2.1.

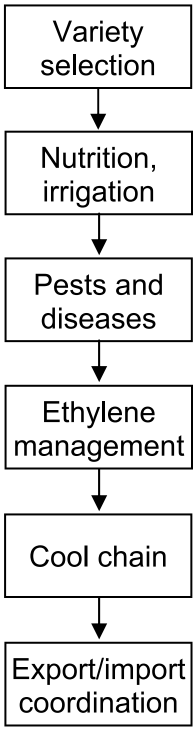


Figure 2.1. Quality flowchart

Quality management

Variety selection

Having a mix of varieties that spreads the flowering time will mean that harvesting/packing facilities will be able to cope with picking/handling demands.

Planting too much of one variety will require a larger picking/processing capacity that may be idle for most of the year. Inability to harvest and process the crop at the right time will result in loss of stems and a deterioration of quality through delays in picking and harvesting.

Spreading the flowering time of varieties will also have the advantage of spreading supply and risk associated with fluctuations in the market.

Nutrition and irrigation

Nutrition and irrigation have a large bearing on the length, number, thickness and quality of stems produced. The optimum nutrient tissue levels for waxflower are discussed in Chapter 7. Achieving these levels in the plant will ensure that stem growth is maximised.

Soil pH needs to be managed so it remains around 5.5 to 6.5 (1:5 water extract) to ensure nutrients (particularly certain trace elements) are available and plants develop a healthy root system. A low soil pH can stunt root growth and limit the amount of water and nutrients a plant can absorb, affecting growth.

It is also important to have an efficient irrigation system that is able to meet crop demand for water. Waxflower water requirements depend on growth stage and plant size. Tensiometers are invaluable tools for ensuring plants are receiving adequate irrigation (see Chapter 6).

It is also important to check water quality; levels of salt above 162 mS/m (891 ppm) start to affect waxflower growth. Generally, waxflower is best grown on salt-free soils with EC below 115 mS/m.

Pest and disease control

Exported waxflower is subject to strict quarantine checks, particularly in Japan and the United States. If pests or diseases are detected, it will result in the fumigation or destruction of flowers at cost to the grower or exporter.

Pests and diseases in consignments can also cause damage to flowers and leaves or may lead to flower drop (for example, from botrytis). An integrated pest management approach (IPM) will reduce the risk of this type of damage.

Flowers will require inspection if being sent to markets in the United States or Japan. This can be done at the central packing shed or on-farm after setting up a sampling system with state quarantine authorities. A phytosanitary certificate needs to be issued confirming the insect-free status of flowers.

For disease, a preventative spraying program is needed prior to and during months of high disease risk. For insects, an integrated pest management (IPM) approach works best where insect numbers are monitored and sprayed in the field only when numbers reach a certain level.

The spray program reduces insect numbers allowing the postharvest system to effectively control and remove any insects remaining on flowers at harvest (see Chapter 14).

Harvesting and handling

Efficient harvesting minimises moisture loss and allows stems to be processed easily and efficiently.

Having different varieties with staggered flowering times to meet production orders will reduce the demand on labour and facilities at one particular time.

Varieties that flower during winter and early spring have a lower risk of drying out. Harvesting may need to be managed to ensure that stems are not wet from dew or rain when brought into the shed, as this will affect solution uptake during postharvest processing.

Varieties that flower during the warmer months should be processed to ensure that they don't overheat or dry out by picking early in the day, shading trailers and trying to pick before a hot spell.

Some form of cooling in the packing shed may be needed to prevent flowers heating up and to prevent excess uptake of postharvest solutions such as sodium thiosulphate (STS).

Installing sprinklers on the roof or using wet curtains that cool the air blowing across them is simple and cheap. Consider separating an area of the shed where solution uptake occurs so that the whole shed doesn't have to be cooled.

Care needs to be taken to ensure the product is uniform—one poor bunch will discount the whole lot.

Packaging

Packaging has been shown to be important for number of reasons.

It allows the mixing of different flowers into cartons to reduce handling and allow through freight. Different carton sizes in different markets will also help.

Distinctive cartons, for example using colour or labelling, can also make products stand out.

Labelling bunches with varietal names and giving unique or different wrapping to specific florists may help create loyalty. The branding of product works to create loyalty—this can be on a state basis or by individual exporter or grower.

Maintaining the cool chain

All stages of industry expect the same quality and freshness that can only be obtained through keeping temperatures cool right through the chain.

Cooling flowers reduces respiration, helps to preserve flower quality and improves vase life. Since the cool chain starts in the field, it will be easier to maintain during processing by reducing field heat initially.

Once the flowers are packed they should be cooled to 2 °C as soon as possible. The quickest way to achieve this is by forced air cooling. A forced air cooler brings down flower temperature in 20 minutes compared to 1–1.5 hours using a conventional cool room. A forced air cooling system is simple and inexpensive and can be built into an existing cool room (see Chapter 15).

Cool temperatures need to be accompanied by ethylene scrubbing. This is particularly important when the ethylene sensitive flowers are transported with other commodities such as fruit and vegetables.

Flowers should be transported in refrigerated trucks. This is particularly important where flowers are being transported long distances from farms.

Once flowers leave Australia, there is little control over whether they are kept cold or not, but forward planning can reduce the risk of flowers overheating.

Time your shipments so that flowers do not arrive on an off-day, which can cause a delay in processing.

Cover flower pallets with insulated foam and add dry ice to maintain low temperature. If flowers are being transhipped they can be cooled en route.

Temperature loggers are useful for determining the temperature history of flowers to work out better transport strategies.

Export-import coordination

To ensure flowers reach export destinations fresh, flowers need to be handled quickly and smoothly. All documentation and export arrangements need to be correct as this can minimise the time flowers sit at an airport either heating up or freezing because of confusion over paperwork. The areas needing to be coordinated are shown in the flowchart in Figure 2.2.

Consignments need to be clearly marked showing details of variety, length and numbers of stems or bunches (Figure 2.3). Signage on the flower carton should also show that flowers should be kept cool (1 to 2 °C) and some handling information on preserving vase life.

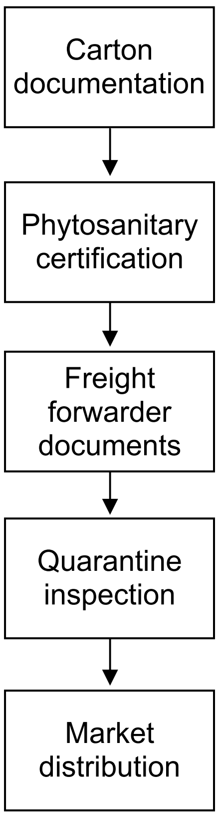


Figure 2.2. Export–import flowchart

Figure 2.3. Flower cartons showing required information printed on exterior

Consignments need to be accompanied by clear documentation, including phytosanitary certificates and freight forwarding information.

Destination of flowers needs to be checked and clearly marked on documents. When the consignment arrives, notice must be relayed to the import agent and wholesaler so flowers may be distributed quickly.

If growers are exporting, it is good practice to provide the importers or exporters with an estimate of the quantities of flowers that will be available for sale during the year. This will help the importer or exporter to seek out markets ahead of time so that over- or under-supply situations do not occur.

Record keeping

To help estimate future production requirements, it is very useful to keep a record of the performance of varieties in terms of yield.

Growers should compare the performance between their own varieties—in terms of price and demand—on overseas markets and gather information on market performance.

This will help determine whether to keep a variety, to increase planting or to move into different or new varieties.

To maintain market share, 10–20 per cent of a farm should be continuously replanted with new varieties.

The feedback loop

The most effective tool in quality management is the feedback loop, linking the grower with the consumer and others in the supply chain.

Developing links to your customers means that if there are any quality concerns, they can be investigated to work out where improvements or changes need to be made along the supply chain.

- Are the varieties themselves meeting expectations and requirements?
- Are postharvest treatments sufficient?
- Was there a delay or severe temperature fluctuation during transport?

Ask your buyer to provide you with comments on the performance of each consignment and link this information with your crop and postharvest records.

For example, florists deal direct with the consumer and get immediate feedback. They are also held more accountable for quality and vase life than bulk retailers and casual outlets. While customers will return flowers to the florist for a refund if they are not satisfied with the quality or longevity, they would not return to the supermarket for a refund. This has to do with expectations of professionalism—florists are specialists and are expected to know the product.

Further reading

Department of Agriculture and Food, Western Australia:

- Farmnote 47/2004 *Flowers—giving the market what it wants.*

Waxflower—quality checklist

☑ Liaise with your buyer (confirm your market—what do they need)

☑ Identify varieties to be grown — Ch 3
- market demand and trends
- is it suited to your growing conditions?
- does it complement other varieties you have?
  - colour
  - seasonality (picking time)

☑ Set planting date — Ch 4

☑ Order plants (time management) — Ch 4

☑ Site preparation — Ch 4
- site windbreaks
- weed control
- irrigation layout
- fertigation set-up

☑ Planting — Ch 4
- wet up soil
- check each plant for
  - root binding
  - vigour
  - plant height
- erect seedling windbreaks (cones)

☑ Field management — Ch 4
- pruning for maximum yield and stem length — Ch 5
- irrigation for yield and longevity — Ch 6
- nutrition for stem length, flower display and leaf colour — Ch 7
- insect control for damage-free flowers — Ch 8
- disease control for improved vase life — Ch 9
- weed control for optimum water and nutrient usage — Ch 10

☑ Harvest timing and techniques to preserve flower quality — Ch 11

☑ Postharvest treatments in the field and in the shed
- ethylene management for improved vase life — Ch 12
- devitalisation to protect new varieties — Ch 13
- postharvest insect and disease control for export — Ch 14
- cool chain — Ch 15

☑ Delivery—storage and transport options to maintain cool chain — Ch 16

☑ Feedback loop (What did the end user think? What did your buyer think? How does this information help me to improve my flower management?)

3. Variety selection

Variety selection essentials

Talk to your buyer—what do they need?

Does the variety:

- meet current market trends and demands
- meet future predictions for market trends and demands
- suit your growing conditions
- complement your other varieties in terms of:
  - agronomics (same fertiliser and irrigation requirements)
  - colour
  - seasonality (picking time).

Species and variety selection

To stay competitive and command premium prices on export markets, new, high quality varieties of waxflowers are essential. Growing the right mix of varieties is necessary to maintain market share.

Certain varieties command up to a 25 per cent price premium. This has been the case for Pearlflowers and especially late flowering varieties of waxflowers.

In planning a waxflower plantation, decisions need to be made on what varieties to grow. With more than 100 varieties of waxflowers under cultivation, and new cultivars being released each year, the choice is not easy.

When selecting your variety mix, consider:

1. market demand and supply—how popular is the variety with buyers and how many others are growing it?
2. seasonal advantage—farm location may give your variety early or later flowering (there are indications that waxes flower earlier in more northerly locations of Western Australia)
3. flower colour mix—it is ideal to have white and pink varieties available over an extended season
4. flower size and form—different markets may prefer small or large, double or single (see Figure 3.1)
5. flower arrangement on stem—terminal flowering or more evenly distributed along stem (racemose)
6. productivity—stem length, stem thickness, number of stems per plant as well as number of stems per 400 gram bunch
7. disease resistance or susceptibility—varietal differences and climate conditions may give different responses to diseases such as powdery mildew, *Botrytis* or *Alternaria*
8. response to water and fertiliser—for example, there is some limited evidence that *Verticordia x Chamelaucium* hybrids may have a lower tolerance or requirement for phosphorus
9. vase life—long or shorter in relation to market destination
10. ethylene sensitivity and need for anti-ethylene treatment (STS or 1-MCP).

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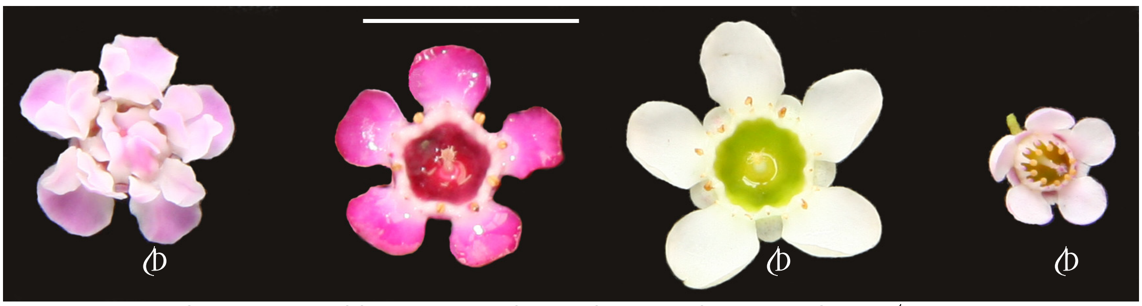


Figure 3.1. Comparison of flower types (from left right) of Dancing Queen Ⓓ, Purple Pride, Bridal Pearl Ⓓ, and Southern Stars Ⓓ *(white bar = 22 mm)*

There are four main groups of waxflowers from which you can choose your variety mix:

A. *C. uncinatum* and intra-specific (*C. uncinatum x C. uncinatum)* hybrids—varieties like Purple Pride, Alba and Jurien Brook

B. *C. floriferum* hybrids—Snowflake or Lady Stephanie; and *C. axillare* hybrids—My Sweet Sixteen

C. Inter-specific (*C. uncinatum* x *C. megalopetalum*) hybrids including the Pearlflowers—Denmark Pearlȸ, Crystal Pearlȸ or Laura Mae Pearlȸ

D. Inter-generic hybrids (*Chamelaucium* x *Verticordia*) including Jasperȸ and Southern Starsȸ.

Other species of *Chamelaucium* are sometimes used as cut flowers:

- *Chamelaucium megalopetalum* (large waxflower)—large white flowers that age to pink, red or purple with yellowy-green centres. Newer selections may improve the commercial viability of this species. The flowering season is September to October.
- *Chamelaucium ciliatum* (Stirling wax)—white to pink flowers. Native to a wide range of soil types, including gravel and clay soils. Periodically popular. The flowering season is September to November.
- *Chamelaucium floriferum* (Walpole wax)—pinkish-white flowers with purple centre. The flowering season is August to November.

There are many waxflower varieties available, and growers should contact DAFWA, exporters, nurserymen and grower associations for advice on the best selections to grow.

Future developments will see a wider range of colours available all season, and the increased planting of improved hybrid varieties.

Flowering time and seasonality

Chamelaucium uncinatum is the most widely cultivated of the waxflowers. Varieties are available to give a flowering season from June to November in traditional waxflower growing areas of Western Australia.

The precise time of flowering depends on the variety grown and the season. Day length and temperature affect flower initiation and temperature affects time to flowering.

Generally, waxflower varieties tend to flower earlier when they are grown further north, however, local conditions have a large bearing on when a variety will flower (for example, warmer conditions closer to the ocean enhance flowering). Use local knowledge of flowering times to select your varieties.

Pearlflowers

Figure 3.2a. Highly marketable bunch of Denmark Pearlȸ flowers

Figure 3.2b. Highly marketable bunch of Gemflowers, variety Purple Gemȸ

There are several varieties available in the Pearlflowers (Figure 3.2a) and Gemflowers (Figure 3.2b) which are highly marketable and have a range of flowering times from June/July to September/October depending on location. New varieties are extending this seasonal range, with Pearlflowers available for more of the year. Other new varieties such as the Gemflowers are being bred to increase the colour variation available.

The breeding program at DAFWA has produced new hybrid waxflowers such as the Pearlflowers, which have certain advantages over the old *C. uncinatum* varieties (Figures 3.3a and 3.3b).

Pearlflowers have a number of superior features and are adaptable to a wide range of environments. They also have an advantage in terms of marketability. Recent advances in breeding (Table 3.1) have increased production by:

- extending the season with improved availability
- increasing yield and response to correct irrigation and nutrition
- increasing the colour range over the whole season to ensure continuity of supply
- improving display, with large solid flowers on terminal heads giving a dense display
- reducing on-growth or grow-past, that is, growth of leaves past flowers
- reducing susceptibility to pests and disease
- considerably increasing vase life making for better export quality.

More than 200 cultivars have been grown over the past 20 years and now, over 100 varieties are sold as cut flowers.

Figure 3.3a. Open flower habit of C. uncinatum variety CWA Pink

Figure 3.3b. Dense terminal flower head of Bridal Pearl⊕

Table 3.1. Comparison between characteristics of natural and hybrid type waxflowers

Characteristic	**Natural waxflowers**	**Hybrid waxflowers**
Form	Open raceme	Compact corymb
Colour	White, pink, purple	White, pink, purple with patterns and shade variation, wide colour range
Vase life (days)	7–10	17–30
Shattering—*flower & bud drop*	90–100%	20–65%

Table 3.2. Pearlflower, Gemflower and Starflower varieties

Pearlflower variety		**Flowering time***	**Characteristics**
Bridal PearlΦ		Very early season mid-June to mid-July	This Pearlflower hybrid is popular with the industry because it is one of the earliest flowering varieties. It grows as a bushy plant with terminal white, waxy flowers. Flowers age from white to tinges of red. The vase life is superior to normal waxflower varieties.
Esperance PearlΦ		Early season end June to end July	Esperance PearlΦ blooms just after Bridal PearlΦ in most seasons. It grows as a bushy plant with terminal, white, waxy flowers and pink buds. Flowers have a lemon centre but this turns darker with age. The vase life is superior to normal waxflower varieties.
Denmark PearlΦ		Early to mid-season July	This hybrid fills the niche between the earliest Pearlflowers and the later varieties. It has terminal, white, waxy flowers with lemon centres and long stems. The vase life for the cut flowers is superior to normal waxflower varieties.
Albany PearlΦ		Early to mid-season July to August	Albany PearlΦ has terminal corymbs of crisp, creamy-white flowers with yellowy-green centres. Flowers do not develop colouration with age (such as occurs with Bridal PearlΦ and Esperance PearlΦ). This variety has an extended vase life.
Laura Mae PearlΦ		Mid to late season mid-July to mid-August	This hybrid has terminal, crisp, creamy-white flowers with elongated petals, a yellowy-green centre and very upright, long stems with terminal flowers. Laura Mae PearlΦ has an extended vase life.

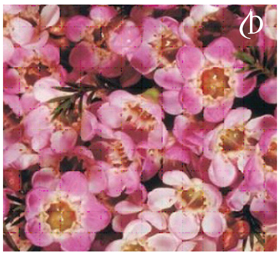
** flowering times of all varieties determined at Medina Research Station, Western Australia*

Table 3.2. Pearlflower, Gemflower and Starflower varieties (continued)

Pearlflower variety		Flowering time*	Characteristics
Crystal Pearlⓟ		Mid to late season August	Crystal Pearlⓟ has clean white flowers with lemon centres. It has a long flowering period with an excellent vase life.
WX 74ⓟ		Mid to late season mid to late August	This variety has clean white flowers with lemon centres. It is a high yielding variety that flowers on finer stems. A feature of this flower is that it retains a vibrant green leaf colour as it ages. It has an excellent vase life.
WX 87ⓟ		Late season September to October	The latest flowering Pearlflower, WX 87ⓟ extends the Pearlflower season to October. It has clean white flowers with lemon centres on long, strong, upright stems. This hybrid has an excellent vase life.

** flowering times of all varieties determined at Medina Research Station, Western Australia*

Table 3.2. Pearlflower, Gemflower and Starflower varieties (continued)

Gemflower variety		Flowering time*	Characteristics
WX 56Ⓟ		Early season July	A stunning Gemflower with a lemon centre. The flower ages from white and darkens to a pink/mauve colour. It has an excellent vase life and can be picked white or pink.
Pastel GemⓅ		Early to mid-season mid-July to mid-August	Flowers have light pink petals with pink to red centres. This hybrid has a long vase life.
Purple GemⓅ		Mid-season late July to August	This Gemflower hybrid grows as a bushy plant and its main feature is the terminal, dark pink/purple waxy flowers. Excellent vase life.
Starflower variety		**Flowering time***	**Characteristics**
JasperⓅ		Late season October	Small, *Verticordia*-like, terminal flower clusters. This variety has dark pink petals with maroon centres. It has a long vase life and low flower drop.
Southern StarsⓅ		Very late season October to November	A small flowered, high yielding pink variety with terminal clusters of flowers on long stems. Other desirable characteristics include long vase life and low flower drop.

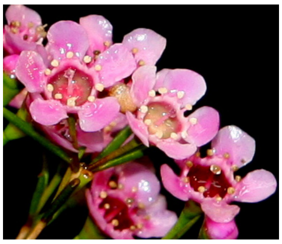
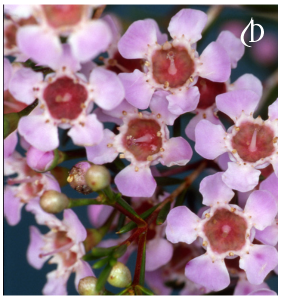
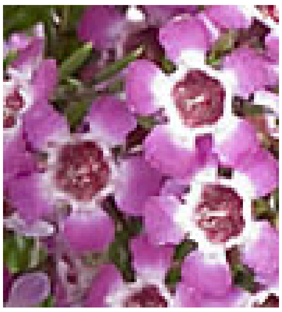
** flowering times of all varieties determined at Medina Research Station, Western Australia*

Table 3.3. Budwax varieties

Budwax variety		**Full bud appearance***	**Characteristics**
Lemon Drops		Very early season mid-May	Delicate, lemon coloured bud topped with ornate awns. Opens to a white flower.
Purple Gem⦶		Very early season late-May	Medium sized, rounded, red, terminal buds that open to a deep pink flower.
Laura Mae Pearl⦶		Early season June	Large, rounded golden-yellow terminal buds, that open to crisp, creamy-white flowers.
Painted Lady		Early season mid-June	Large, rounded, bright red, terminal buds that open to bright pink flowers.

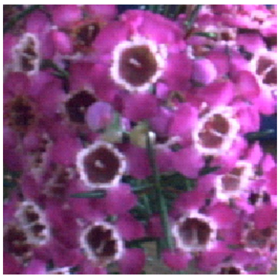
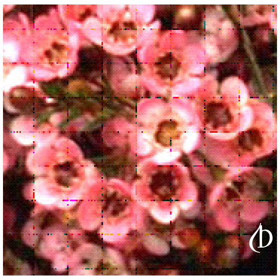
** full bud appearance of all varieties determined at Medina Research Station, Western Australia*

Table 3.4. Some other commercially available varieties of waxflowers

Variety		Flowering time*	Characteristics
CWA Pink		Very early season June	Usually a vigorous, untidy plant with non-terminal, pink flowers. Some other pink selections may go under the same name. It has sold well in the past because it is early flowering, however sales have declined recently due to the availability of newer hybrids.
Early NIR		Early season June to July	Pale pink, medium to large flowers with dark centres. This selection of *C. uncinatum* has a vase life of 14 to 21 days.
Revelation		Early season late June to July	This variety was one of the first of the Pearl/Gemflower types to be released to the market. It has an excellent display of terminal, waxy pink flowers with a superior vase life. It is lower yielding than other similar varieties. Could potentially be grafted onto a more vigorous rootstock.
Jurien Brook⏀		Early to mid-season July to early August	Medium sized mauve flowers with a red centre. Similar to Mullering Brook in appearance but flowers earlier.
Purple Pride		Early to mid-season July to August	Purple flowers with a white central ring. May include a number of different selections. The most widely grown wax variety.

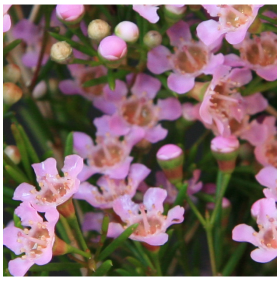
** flowering times of all varieties determined at Medina Research Station, Western Australia*

Table 3.4. Some other commercially available varieties of waxflowers (continued)

Variety		Flowering time*	Characteristics
Eclipse		Early to mid-season July to August	Similar to Purple Pride with a white central ring on the flowers. Eclipse appears to have some resistance to dieback (phytophthora).
Painted Lady		Early to mid-season July to August	Sold as budwax or cut flower. Spectacular scarlet red buds that open into bright pink blooms.
Purple Giant		Early to mid-season July to August	Extremely large purple flowers, with a vase life of 14 to 21 days.
Teina's DelightⓅ		Early to mid-season July to August	Medium sized apricot to red flowers, with a vase life of up to 21 days.
Lilac Spring		Mid-season July to October	Lilac Spring is a *C. uncinatum* selection with large lilac to mauve flowers. This variety has a vase life of up to 21 days.
Raspberry RippleⓅ		Mid-season August	A mid-pink variety that has a vase life of 8 to 14 days.

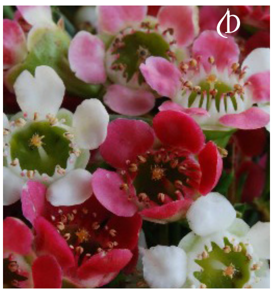
** flowering times of all varieties determined at Medina Research Station, Western Australia*

Table 3.4. Some other commercially available varieties of waxflowers (continued)

Variety		Flowering time*	Characteristics
Alba		Mid-season August to September	Alba is a very vigorous white flowering variety that has problems with leaf yellowing and on-growth. A number of different selections are available. Grown widely in the past, it is becoming less popular due to competition from newer, white flowering Pearlflowers.
Ivory Pearl		Mid-season late August to early September	This Pearlflower hybrid has large terminal, white, waxy flowers with a superior vase life. Leaves tend to yellow with age.
Mullering Brook		Mid to late season September	Mullering Brook has small, pink flowers and is more upright and long-stemmed than other varieties. Several different selections are grown under this name.
Chantilly Lace		Mid to late season September to October	This variety has a medium sized double white flower and a vase life of 8 to 14 days.
Eric John		Late season mid-September to October	The first of a series of compact *Verticordia*-waxflower hybrids with small terminal flowers. Not widely grown. Others in the series include Jasperⓓ, Southern Starsⓓ and Paddy's Pink.
Dancing Queenⓓ		Late season late September to October	This variety has mauve to pink 'double' flowers which add a different, softer character compared to other waxflowers on the market.

** flowering times of all varieties determined at Medina Research Station, Western Australia*

Table 3.4. Some other commercially available varieties of waxflowers (continued)

Variety		Flowering time*	Characteristics
Lady Stephanie		Late season September to October	Lady Stephanie has smaller, pink flowers with green centres that age to dark red. Upright in form, with flowers along short branches up the stem, it is a hybrid between *C. uncinatum* and *C. floriferum*. It has remained reasonably popular over time.
Paddy's Pink		Late season September to October	This mid-pink *Verticordia*-waxflower hybrid has larger flowers than Eric John. It has upright growth with tight clusters of flowers on terminal heads.
White Fire		Late season September to October	This hybrid has very small white flowers similar to Lady Stephanie but with light coloured flower centres.
Lady Jennifer		Late season September to October	A small, pink flowered *C. floriferum* hybrid with dark red flower centres. Masses of small flowers occurring among the dense needle-like leaves. Tends to develop on-growth.
Cardinal Chris		Late season September to October	Deep maroon flowers with yellow centres that age to deep maroon. Similar size flower to Purple Pride. Moderate vase life of 7 to 10 days.
My Sweet Sixteenⓟ		Very late season October to November	White flowers which age through pale pink, rich pink to red, with a superior vase life. It has an upright to bushy form. This is a three-way hybrid with *C. axillare*, *C. floriferum* and *C. uncinatum*.

** flowering times of all varieties determined at Medina Research Station, Western Australia*

Table 3.4. Some other commercially available varieties of waxflowers (continued)

Variety		Flowering time*	Characteristics
Snowball		Very late season October to November	Small cupped white flowers with green centres. This variety has a moderate vase life.
Mullering Brook White		Very late season October to November	A later flowering white version of pink Mullering Brook. Medium sized open clean white flowers with lemon-green centres and a moderate vase life.
Pearl Buttons		Very late season October to November	The latest flowering white waxflower, Pearl Buttons is small flowered variety with a vase life of 8 to 14 days.
Blossom Fireball		Very late season October to November	Dense heads of small white flowers that turn deep red with age. Blossom Fireball is a hybrid type with a vase life of 14 days.
Vesuvius(þ		Christmas wax season late October to December	An extremely late flowering hybrid with small, dense flower heads of blooms that age from white to red. Vase life of 14 to 21 days.

** flowering times of all varieties determined at Medina Research Station, Western Australia*

Tables 3.2, 3.3 and 3.4 are not intended to be an exhaustive list of waxflower varieties, however, they provide an indication of the types of varieties that are available.

Thanks to Brian Jack of Western Flora and Craig Musson of Helix Australia for providing photographs and information on a number of varieties.

Variety selection for disease resistance

Where soil-borne disease such as dieback (*Phytophthora* spp.) is present, it may be possible to select phytophthora resistant varieties such as Eclipse (see detail in Table 3.4).

Phytophthora resistant varieties and Pearlflowers grafted onto resistant rootstocks have been used successfully in Queensland. These plants appear to yield at least as well as non-grafted Pearlflowers (Seaton unpublished).

However, preventing the introduction of disease onto your waxflower property by implementing an effective biosecurity plan is still the most effective strategy.

Yields

Many factors affect waxflower productivity including fertiliser use, irrigation, pests and disease. Grower experience in Western Australia suggests that the yields in Table 3.5 can be expected from healthy, well-managed bushes.

Large amounts of waxflowers become available at certain times of the year, such as July and September to October (Figure 3.4).

While you may plan to supply waxflowers outside this peak, the exact flowering of varieties will depend on varietal response to local climatic conditions.

Table 3.5. Yields of Chamelaucium species: Number of 500 g bunches produced per plant*

Species	Year 2	Year 3	Years 4–10
C. uncinatum			
Alba	4	7	15
Purple Pride	3	5	12
CWA Pink	4	6	14
Mullering Brook	3	5	9
Hybrids with optimum management**			
Esperance PearlⓅ	5	12	25
Denmark PearlⓅ	5	10	20
Laura Mae PearlⓅ	5	10	20
Purple GemⓅ	5	10	20
Southern StarsⓅ	3	8	15
Lady Stephanie	3	5	18

** nil production in Year 1*
*** see later chapters for management strategies for hybrid waxflowers*

Note: The number of stems per bunch ranges from 5 to 15, averaging about 8. The price per bunch will depend on flower quality, stem length and stem thickness.

Avoiding gluts in the markets can be tricky. However, planting a range of varieties will reduce the risk of surplus stems at times of over-supply.

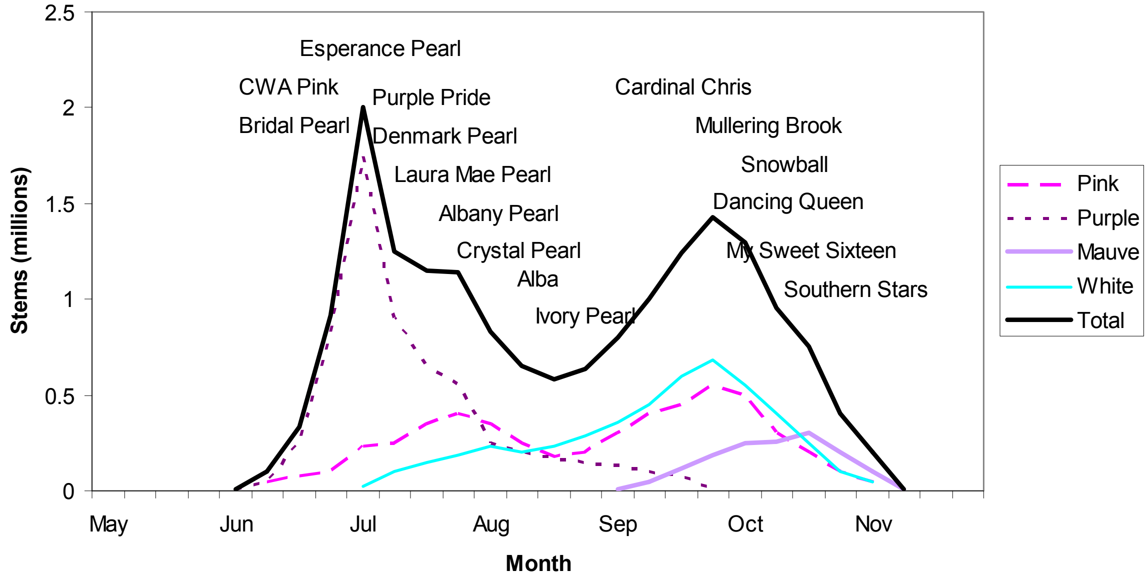


Figure 3.4. Estimated stem production during the flowering season in Western Australia (2009)

4. Establishing and managing your waxflower crop

Establishment essentials

Site selection and preparation:

- northerly aspect to site
- use areas upslope—low frost risk
- well drained soil
- soil pH 5.5 to 6.5
- soil P ≤ 20 ppm
- soil free from weeds and disease.

Design and install irrigation and fertigation:

- trickle irrigation preferred or micro-sprinklers if sufficient water
- budget water resources (current and future requirements)
- do a full test run to be sure the system works well before planting.

Select and order your tube stock:

- set a planting date
- order your tube stock ahead of the planting date (3 months)
- avoid using old tube stock (best between 3 and 6 months old)
- aim at planting in warmer weather (September to November or March to April) for optimum growth.

Establish windbreaks.

Planting tube stock:

- prepare site well before your plants arrive (deep-ripping, weed control, compost)
- wet up soil a week before planting
- examine tube stock on arrival
- discard (return) any root bound plants
- discard (return) any top heavy plants (> 15–20 cm)
- discard (return) any diseased plants, or plants with pale foliage
- plant out seedlings within 2 weeks of arrival.

Plant in single rows:

- use north–south orientated rows
- 1–2 m between plant, within-row spacing (depends on variety)
- 3–4 m between rows (sufficient to allow farm vehicle access).

Establishment essentials…

Management of plants in-ground:

- avoid planting in heat wave conditions
- install individual wind guards for seedlings
- remove wind guards after 3 months
- regularly weed by hand around young plants
- pruning by 30–50 per cent height (after 6 months) to set up optimum canopy shape for maximum production
- apply slow release fertiliser for the first 6 months
- at 6 months gradually introduce fertigation to young plants. Apply one third of the recommended rate weekly, then increase the frequency to every second day.

Waxflower plantations should be established to maximise plant quality while minimising costs. This involves careful planning as well as site selection, site preparation, variety selection, planting patterns, planting bed preparation, irrigation design, fertiliser application, fertiliser programs and spray programs.

It is essential to have the right field equipment and sufficient labour to grow the crop successfully. Peak labour requirements are at planting and harvest/pruning time.

The planting site must be prepared well ahead of planting. This means that weeds and diseases are controlled, deep-ripping completed, lime applied (if necessary), and irrigation piping and mulch are all in place so that planting is not delayed.

Site selection and preparation

The site should be free of disease and weeds before planting.

Site orientation and planting densities

The site should allow for easy vehicle access all year round. Extremely steep locations are not practical for the movement of tractors, spray units and harvesting aids. A northerly aspect is preferred to maximise winter light levels, with rows running north–south.

Frost risk

Waxflower is susceptible to severe frost. If frosts occur during winter when buds and flowers are forming they can affect yield and quality severely.

If the frost risk is high, it is best to select areas of low risk such as up a slope. These areas generally have less frost as cold air drains away into valleys reducing the severity.

There are a number of methods for reducing the effect of frost, though none provide a guarantee as it depends on the severity of the frost.

- **Overhead sprinklers** (see Figure 4.1) are set up above the crop to spray water over the canopy as temperatures fall. To get good crop coverage, most systems use a standard sprinkler with a butterfly head or similar, that sprays water over several metres. This system works provided the frost is not too severe or protracted, however, if sprinklers are left on for too long, the water tends to freeze over the crop.
- **Wind machines** are very effective for frost control but have a high initial set-up cost. They can cover a 100 m radius and work by stirring up air above the canopy bringing warmer upper air down to crop level.
- **Windbreaks** can help protect plants from wind which, when associated with frost, magnifies the effect of the cold. This minimises the probability of frost damage.
- **Frost protection cloths** are fine cloths draped over the waxflower plants in a row. This appears to have some effect depending on the severity of the frost.

Figure 4.1. Frost protection system using overhead sprinklers in a waxflower crop

Soil type

Waxflower is endemic to the south-west of Western Australia, and is mainly found on acidic, free draining, sandy or loamy sands or lateritic soils.

Well-drained soils are essential. Waxflower plants require at least 1 m of friable soil for proper root establishment. Deeper soils are better. Sandy soils overlying a lateritic or gravel layer are also ideal, provided there is 1 m of sand over the gravel.

Loamy soils are generally unsuitable for waxflower plants because of the risk of waterlogging. If the subsoil is compacted or there is a shallow sand layer over impervious clay, it is not ideal for waxflowers. However, it may be possible to use these soils with mounding or soil drainage. Before planting, it is best to dig test holes to determine subsoil structure.

Subsoil moisture

Waxflower is a high water user and benefits from a source of subsoil moisture, such as gravel lenses or a watertable at greater than 1 m.

pH

Slightly acidic grey or yellow sands (pH 5.5 to 6.5) are the most suitable for growing waxflowers. Saline soils or those with low pH (< 5.5) or high pH (> 7.5) are not ideal.

Production becomes restricted where soil salinity is greater than 10 mS/m or where irrigation water has a salinity of 360–500 mS/m (800–1500 ppm total soluble salt). If saline water is used, it is important to flush the lines with clean water once a week to remove salt build-up from around the plant roots.

Previously cultivated sites

Sites which were previously used for pasture or crop can be used, but these will require more preparation than sites that have not been cultivated. Nutrient history, hardpan and weed burdens are all influenced by prior land use.

If using new land permission must be obtained from the Commissioner of Soil Conservation before clearing.

Armillaria infestation is more common on uncultivated land, therefore sites should be tested before planting.

Nutrient history

Previously cultivated soils should be tested for phosphorus (P) levels. Records from cropping or pasture fertiliser history will indicate this. Levels of P less than 20 ppm are desirable.

Although waxflowers generally tolerate moderate levels of P, hybrids between *C. uncinatum* and *Verticordia* such as Eric John, Jasper(b and Southern Stars(b may be more sensitive to P levels and be unsuitable for growing where there is high residual P from previous pasture or cropping.

Hardpan

Cultivated and pasture land often develops a hardpan near the surface, preventing good root establishment. These soils will require deep-ripping to below 50 cm to break up the soil compaction layer.

Weed burdens

It is essential to reduce the weed seed-bank before planting. Effective weed control requires cultivation and herbicide spraying **12 months ahead of planting**.

It is very difficult to remove weeds after establishment, especially broad leaf weeds such as capeweed and doublegee.

The site should be cultivated to stimulate initial weed germination and sprayed with a knockdown herbicide such as Spray.Seed® or glyphosate. If weed seed load is high, this process should be repeated until the weed load is low.

Dieback

Phytophthora cinnamomi (jarrah dieback) and related species are the major soil diseases affecting native plants. As it is extremely difficult to eradicate *Phytophthora* once soil or plants are infected, it is important that the site chosen is free of the disease. Private laboratories or DAFWA can test soil and water for a range of diseases for a fee.

If the site is thought to be free of *Phytophthora*, care needs to be taken to prevent introduction of disease through unsterilised soil brought into the production area on implements, vehicles, footwear or animals. It is important to set up hygiene control measures such as fencing off the area under cultivation and using vehicle tyre baths and footbaths at entry points, to ensure soil-borne diseases are not introduced.

Planting stock needs to be purchased from an NGIA-accredited nursery to prevent diseases such as *Phytophthora* being transferred to your property through potting mix.

Mildew

In higher rainfall areas, the susceptibility of a species to mould and mildew is important. For instance, *C. uncinatum* x *V. plumosa* hybrids appear susceptible to powdery mildew infection when conditions are warm and damp. Whilst the fungus can be controlled to an extent with fungicides, this adds another cost.

Propagation

Most new waxflower varieties will be produced by licensed propagators.

Tube stock management

Starting with healthy tube stock is critical to successful plantation establishment. It can affect not only the longevity of the plant, but impact significantly on the stem yield as well. The following phases of tube stock management, need to be considered:

Healthy tube stock

Tube stock must be free from root spiralling—the way plants are propagated is critical. Propagation tubes need to train newly initiated roots such that they do not spiral but are deflected and guided downwards to the bottom of tubes (Figures 4.2a and 4.2b).

Request that your seedlings are supplied in tubes that are of good container design with features including:

- root trainer ribs
- splayed corners
- cell volume of 30–50 cc
- air slots on side walls
- open base to cell
- tapered walls to at least 3–7 degrees
- vertical ribs running down the container wall
- large hole at bottom of the container
- more open cell arrangement to allow for good ventilation.

Trays of plants should be placed on mesh benches to allow air pruning of roots that appear out of the tube.

Figure 4.2a. Tube stock with healthy roots

Figure 4.2b. Poor roots (root spiralling)

No planting delays

Minimise the time lapse between when roots are initiated, and planting (no more than four to six weeks). Long delays in planting, with plants left in propagation tubes will cause root binding and greatly diminish the health of tube stock.

It is not worth planting overgrown tube stock that are root bound or have large tops as these plants will have seriously compromised health and ongoing productivity issues. Plants will not recover and will most likely develop tight root binding that will eventually kill them.

Planting bed preparation

Attention needs to be paid to planting bed preparation beyond just weed control.

Deep-ripping

Test the site—if a compaction layer or subsoil clay layer is found, deep-rip the soil. This will allow an extensive mature root system to develop. Just digging a planting hole in a compacted soil is not good enough as this will effectively put the plant in a ‘pot in the ground’ severely restricting root growth.

Compost

In soils with little structure, the addition of organic matter, such as compost, can increase the water-holding capacity, aeration and nutrient availability. However, there is little evidence at this stage to suggest that waxflowers benefit from the effects of compost.

Drainage

The planting bed may need to be raised if surface drainage is a problem. If subsoil drainage is the issue, deep-ripping may be required.

Summary: planting for successful establishment

- Ensure ahead of planting that the site is free of disease and weeds.
- Install irrigation before planting to ensure new plants are adequately watered and to prevent the soil surface from drying out.
- Only plant healthy tube stock. Root-bound tube stock is not worth planting, and any tube stock with root matting at the base may need to be root-pruned before planting.
- Minimise the time plants are held before planting out in the field.
- Plant in warmer weather when soil temperatures are above 10 °C, to encourage early growth.
- Have a fertigation system in place so that fertilisers can be delivered to plants via the irrigation lines (this allows fertilisers to be applied and mixes to be adjusted according to plant needs).
- Adjust fertiliser mix for young plants to one-third of that for mature plants to prevent salt build-up around roots.
- Protect new plantings with windbreaks such as tree guards or cones.

Plant spacing

Determine planting density to maximise bed cover while enabling management of plants. This will depend on the variety.

In-row spacings depend on the crop canopy at maturity. Spacings between the rows need to be sufficient to allow vehicle access for pruning, harvesting and spraying once the plants are mature.

This is usually 4 m between centre lines of rows. Single rows are preferred to double rows as it allows easier weed control, spray penetration and harvesting.

Intra-row spacing (between plants within a row) depends on the variety:

- Large varieties such as *C. uncinatum,* for example, Alba or Purple Pride, are usually spaced at 2 m between plants.
- Gemflowers are spaced at 1.5–2 m.
- *C. megalopetalum* hybrids such as Pearlflowers, are spaced at 1–1.5 m between plants in single rows.
- Some C. *uncinatum* x *Verticordia* hybrids (Southern StarsⓅ) need spacings of 1 m between plants in a single row.

Double rows are not recommended as they make pruning, harvest and management more difficult. If you do plant in double rows, allow an extra half metre between plants within each row and plant in a staggered pattern (see Figure 4.3).

A number of plant spacing options and their equivalent plant density are shown in Table 4.1.

Figure 4.3. It is more difficult to maintain waxflowers planted in double rows

Irrigation design

Trickle irrigation or micro-sprinklers are the most efficient means of irrigating waxflower plantations.

Professional advice should be obtained on the specifications of pumps, filters, pipe diameters and fittings from a company supplying irrigation equipment. Long-term plans for the property should be considered in the design to ensure the system is capable of delivering adequate water should planting be extended or species changed (see Chapter 6 on irrigation of waxflower crops).

Windbreaks

Strong winds (over 28 km/h) can limit both the quality and yield of crops. Adequate wind protection improves quality and yield, and may assist in the successful production of premium waxflowers.

Windbreaks are of real benefit in the establishment of young plants. Damage from wind events includes sand blasting, dislodging of plants and/or stem splitting—particularly in late summer and autumn.

Good windbreaks filter the force of the wind, deflecting most of the wind upwards but allowing some wind to pass through. The deflected wind then descends some distance from the windbreak, providing an area of protection.

Wind protection can benefit crops by changing the microclimate through:

- warmer daytime temperatures
- increased humidity
- reduced evaporation losses through transpiration
- shading during day
- protection from soil radiation loss at night.

There are two main types of windbreaks used in horticultural production:

- trees in hedgerows
- artificial barriers such as shade cloth or other semi-permeable fabrics, that can be used in rows or as individual plant covers.

Tree windbreaks

Trees need to be established well before the crop is planted. While tree windbreaks are cheaper than artificial windbreaks, they may:

- harbour pests and diseases (especially if the windbreak plant is closely related to your crop species)

Table 4.1. Density of waxflower plants with different inter-plant and between-row spacings

Planting arrangement	Intra-row plant distances (m)	Between-row distances (m)	Plant density (per ha)
1	1	4	2500
2	1.5	4	1667
3	2	4	1250

- prevent natural flow of air in frost-prone areas
- compete for water and nutrients (requiring occasional deep-ripping to prune lateral roots)
- require maintenance (replacing trees before they become less effective).

Establishment

- Select the right species. Trees or shrubs should suit local conditions, be water efficient, grow fast, survive long-term and provide good protection at ground level. Trees with poor or no lower canopy need an understorey species to eliminate gaps.
- Plant your windbreak species a couple of years before your crop. The ground must be deep-ripped along the planting line, weeds must be controlled, seedlings must be checked to ensure they are not root-bound and trees spaced appropriately (1.5–2 m apart for most species, but 3–4 m apart for eucalypts).
- Use fertiliser and irrigation to improve establishment.
- Plant the windbreak at least 10 m from the edge of the crop to reduce the effects of shading and root competition. If planted to the north of the crop, increase this distance to reduce shading in winter.
- Roots should be pruned periodically by deep-ripping. North–south orientation of the windbreak will help to reduce shading of the crop.

Tree windbreaks protect your waxflower crop from wind damage and have the benefit of increasing biodiversity on your property. They may also provide a habitat for beneficial species such as birds and predator insects that will feed on pest insects in your crop.

Trees also provide protection from the sun for harvested flowers and for pickers. You may also be able to select a species that you could prune and market as a foliage, flower or ornamental nut.

Further information on tree species may be obtained from DEC or DAFWA.

Artificial windbreaks

While they are more expensive to establish, artificial windbreaks have a known porosity, can be erected quickly, are relatively low in maintenance requirements, can easily be positioned within an existing waxflower crop without having to remove plants or sacrifice larger areas of land and don't harbour pests and diseases.

Artificial windbreaks are generally not as high as most tree windbreak species, and as a result will need to be installed closer together to work as effectively. The fabric needs to stretch down to ground level (most effective with the bottom of the fabric actually buried in the ground) to control wind.

Windbreak design principles

1. Orientation: positioned at right angles to the prevailing winds.

2. Porosity: height and porosity determine windbreak effectiveness. They need to filter the force of the wind—allowing some wind to pass through but deflecting most upwards. The wind then descends some distance downwind of the windbreak, giving a 'zone of protection' for crops. If the wind is blocked rather than filtered, the result is severe turbulence at the point where the wind touches the soil again. This causes more damage and erosion than if there was no windbreak at all.

It is important to have uniform porosity along the entire length of the windbreak, right to ground level, to that wind is not funnelled. Medium porosity windbreaks of between 40 and 50 per cent are ideal. The effective sheltered zone is between six and ten times the height of the shelter. The ideal windbreak has a porosity of around 50 per cent so that the wind slows down without creating turbulence.

3. Height: the effective height of the windbreak is the height ***above*** the waxflower plant. So a shade cloth windbreak structure that is only 2 m tall, has an effective windbreak height of only 0.5 m if your waxflower plant is 1.5 m tall.

As a rough guide:

Crop area protected = (windbreak height – crop height) x (6 to 10)

4. Fabrics: mesh or fabric products are available in various densities (30–50 per cent). The longest lasting fabrics are constructed with a monofilament yarn and may last for 10 years. Others, such as the knitted or woven flat tape yarn, are cheaper but generally do not last as long.

Synthetic materials can be used to provide permanent, low maintenance wind protection. It is important to fully investigate the material to be purchased, such as its stability under sunlight and high winds, ease of construction and cost.

5. Individual plant wind covers: There are some advantages in using individual wind covers for young plants. These come either as soil cones or plastic cylinders supported by three or four canes (Figure 4.4).

Individual plant covers provide some protection from wind during early establishment and can also deter rabbits and birds from damaging young plants. They should only be used in early stages of establishment and then removed to harden plants up.

Other ways to reduce the damaging effect of wind

To prevent excessive sand movement:

- Avoid cultivation between the rows. At planting, cultivate or use herbicides in strips, rather than laying bare the whole area.
- Consider planting into weed mat or black plastic mulch so that the soil adjacent to the plants is covered.
- Sow an annual crop, such as cereal rye, between the rows to bind the soil and provide short-term wind protection for young plants.

Figure 4.4. Young waxflower with individual plant wind cover

Management of plants once established

Pruning management

Young plants

It is necessary to prune young plants, shaping them to maximise yield as a mature bush.

Young plants should be pruned after first flowering to about a one-third of their height. The aim is to establish bush shape, remove apical dominance and establish a platform for later stem production.

Mature plants

Mature plants should be pruned to ensure even stem production and to prevent the development of woody unevenly thick and thin stems. Plants are pruned to around 350 to 450 mm above the ground (see Chapter 5 on canopy management).

Mature plants should be pruned back after picking to maximise yield for the following season.

Timing of pruning depends on flowering, but it should be noted that delays in pruning may compromise growing time and stem length.

Fertilisers

Although Pearlflowers appear to tolerate moderate levels of phosphorus (P), many other varieties have a lower tolerance.

V. plumosa var. *plumosa* is known to be intolerant of the levels of phosphorus usually recommended for growing waxflowers. As this is the parental species of some hybrids, it is possible these hybrids will also have some of the intolerance to phosphorus displayed by their *V. plumosa* parent. Phosphorus toxicity symptoms are leaf drop and bare stems resulting in reduced stem growth, or even plant death.

Nutrient programs for waxflowers, such as the fertigation injection program for new waxflower plantings in Chapter 7, contain low P levels and would suit waxflower x *Verticordia* hybrids.

Mulching

Mulching provides weed control in early establishment and reduces soil temperature in summer. The use of mulch to control weeds needs to be compared with the cost of labour and chemicals in spray programs.

Possible types of mulch can range from organic straws and mulched trees to plastic and weed mat. Generally, the use of mulch will depend on availability.

Where organic mulch is not available, plastic mulch can be used—white plastic is more suitable in the hotter northern areas and black plastic can be used in southern areas.

Once a row of waxflower plants is established (by the second or third year) mulch becomes unnecessary as the plants shade out weeds.

Time of flowering

Flower development occurs in a sequence of buds forming and developing into flowers (Figure 4.5). This process is dependent on day length and air temperature. Flowers are initiated by longer nights and lower temperatures (<10 °C) and develop with higher light and warmer conditions.

Each variety is affected by a particular season differently. Some varieties, such as Purple Pride, respond to cool temperatures while others, such as Mullering Brook and Lady Stephanie, respond to warmer conditions. Pearlflowers appear to be between these extremes.

Achieving good, even flower production will depend on the weather—preferably a cold winter followed by a warm spring.

Flowering manipulation

Plant management can have a large bearing on the flowering performance of waxflowers. Management factors that can control flowering are:

- Early pruning accompanied by good nutrition and adequate water will produce good stem length over summer.
- Shading can be used to slow the effects of hot weather promoting flower maturing in late season varieties.
- Correct fertiliser and irrigation management are essential for good stem production. Depending on location, water and nitrogen need to be managed to control on-growth and stimulate flowering.

  In Western Australia this means cutting back nitrogen in March, while in Queensland nitrogen must be reduced in February.

During flowering, the nitrogen (N) to potassium (K) ratio (N:K) is important to promote good response. This can be achieved by the use of potassium nitrate rather than urea as well as calcium sulphate to increase calcium levels (see Chapter 7).

Figure 4.5. Flower development showing newly emerged buds and open flowers

Further reading

Department of Agriculture and Food, Western Australia:

- Farmnote 72/2002 *Using windbreaks to reduce evaporation from farm dams.*
- Farmnote 43/99 *Windbreaks for horticulture on the Swan Coastal Plain.*
- Waxflower Conference 2006 16–17 March 2006 Perth Western Australia, pp. 8–9, *Controlling flowering in waxflower crops*

Rural Industries Research and Development Corporation:

- Publication 09/006 *Maximising root quality of waxflower tube stock suitable for field planting*.

5. Canopy management

Pruning essentials

Prune young plants:
- by hand in the first year
- when they reach 300 mm in height
- cutting back to 120–150 mm high.

Do not prune below 120 mm.

Prune mature plants:
- initially to 450 mm in height and then side prune at 60 degrees
- subsequently to 5–10 cm above the last pruning height.

Time your pruning:
- at or straight after harvest to give maximum yield and stem length
- to avoid hot weather.

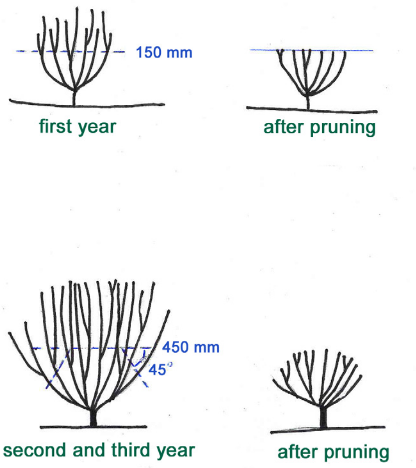


Figure 5.1. Pruning technique for maximum waxflower quality and yield

Prune young plants to shape them to a desirable bush for maximising yield from the mature bush. The mature bush should be pruned back after picking to maximise yield in the next season. Waxflower plants generally yield pickable length stems in their second flowering season.

The time of pruning depends on flowering. Delays in pruning may compromise growing time and stem length.

Avoid pruning during hot weather as this can cause shrivelling of new growth.

Pruning young plants

It is necessary to prune young waxflower plants in their first year, if possible after their first flowering.

Depending on variety, plants should be pruned to around half their height when they reach 250–300 mm, so the young plant will be 120–150 mm high (see Figure 5.1). Do not prune below 120 mm.

Allowing too much vegetative development on immature plants can compromise root development and plants become prone to lodging.

Pruning mature plants

Pruning mature plants is a three cut process—assuming your waxflower plants have been pruned regularly from when they were young.

First—cut back mature plants so that they have a horizontal flat top parallel to the ground at approximately 450 mm.

Second—splay off sides of bushes at an approximate angle of 60 degrees to the ground on both sides so that the cuts at the top almost meet (see Figures 5.2 and 5.3).

If bushes are planted so that they form a solid row, then the second cut can be continuous along the row.

If the bushes are more widely spaced so there are gaps between bushes within a row, then there is also a need to prune off lateral branches. The removal of outward facing lateral branches will force growth upward and encourage straight stem production.

In subsequent years, repeat cutting back to the same level, or 5–10 cm above this level if there are no fresh shoots below last year's cut.

Figure 5.2. Unpruned waxflower plant

Figure 5.3. Top pruned waxflower plant

Cutting back close to the previous level will prolong the productive life of plants and maximise stem length.

Note: If plants are cut back too late (after new shoots have already grown on upper branches) lower shoots will regenerate more slowly.

Timing

Most pruning of mature plants is done at, or directly after, harvest (see Chapter 11).

Timing of pruning is very important as it can determine yield. For every month pruning is delayed after November there is a possible 10 per cent decrease in stem length.

Most active stem growth occurs between late spring and early summer. During this time conditions are warm but not excessively hot, and plants can keep up with evaporative demand (water need).

It is important to prune before the hot weather to:

- avoid new shoots being exposed to the sun and getting burnt
- stimulate new growth and the formation of new roots.

There is then a limited period of ideal growing conditions before the extreme hot weather of late summer and the switch to bud formation in mid-March, which is accompanied by a reduction in stem elongation and vegetative growth.

Pruning at harvest

For most growers, the bulk of pruning is done during the picking process by harvesting to pruning height or by using hedge trimmers to harvest. Operators should be aware of the principles if this is the sole pruning time to ensure no over-pruning (see Figure 5.4).

Figure 5.4. Pruning four year old Ivory Pearl bushes during harvest

Pruning by hand

Most waxflower crops are pruned by hand. Hand pruning is essential for the first two seasons to shape the plant for a lifetime of maximum production.

Mechanical pruning

To reduce labour costs, some growers are using hedge trimmers or tractor-pulled mowers to prune the bulk of the plants (Figure 5.5). Some cleaning up of the plant may then be done manually either with simple secateurs or compressed air-powered shears or pruners.

Crop hygiene

It is important that following pruning, all pruning off-cuts are removed from the site to stop or reduce the spread of insects and diseases.

Pruning waste may be composted and re-used, or burned to reduce the risk of spreading any potential insect (such as gall wasp) or disease (such as canker).

Sterilising pruning equipment (such as secateurs) between blocks can also reduce the spread of disease within a property.

Figure 5.5. Mechanically pruning waxflower variety Purple Pride

6. Irrigation of waxflower crops

Irrigation essentials

Waxflowers respond to irrigation.

Irrigation is critical to stem length, yield and quality, and:
- is essential during the summer months (main period of growth)
- ensures maximum stem length
- avoids crop stress
- is essential for fertigation.

Schedule your crop water needs.

Water use varies with:
- time of year
- farm location and soil type
- evaporation rate
- variety
- stage of growth
- timing of pruning (calculate using formulas in Chapter 6).

Install soil moisture probes (tensiometers) to:
- monitor crop water use
- calculate irrigation frequency.

Determine the type of irrigation system to use.

Design an irrigation system to cope with the water needs of your farm.

Assess your water quality.

It is important to irrigate waxflower crops through summer, which is the main period of growth. Restricting water during active growth stages has a direct impact on stem length for the following season.

Good irrigation management using a well-designed irrigation system is critical for sustained production of high yields of good quality waxflowers.

Water quality

Water should be tested before you start irrigating. The salinity of water is measured by its conductivity in milliSiemens per metre (mS/m)—explained in Farmnote 234 *Water salinity and plant irrigation*.

Saline water can be toxic to waxflowers so irrigation needs to be applied carefully. In freely draining soils up to 10 per cent extra irrigation will flush excess salt accumulation from the root zone. As the salt content of irrigation water increases, higher rates and greater frequency of irrigation will be needed.

For optimum production of waxflower we do not recommend using water in excess of about 162 mS/m.

For drip and micro-sprinkler irrigation, use filtration. The degree of filtration required will depend on the amount of sediment in the water supply and the type of irrigation used. There are many commercial filters available. Regular maintenance of your system will help prevent blockages (see Farmnote 41/90 *Blockages in irrigation lines*).

Types of irrigation systems

There are three main types of irrigation system: drip; mini-sprinklers or micro-jets; and overhead sprinklers. Each of them has advantages and disadvantages. Check with your irrigation designer to find the most efficient system for your planting.

Whatever type of irrigation system you use, it is important that it is calibrated, to know its output. You need to check that each emitter has the same output, pressures along all the laterals are the same or very similar and that the system is capable of delivering sufficient water for your plants.

Irrigation scheduling

Irrigation scheduling involves determining how much water needs to be applied to meet evaporative demand by the atmosphere.

Setting the irrigation frequency and amount of water used each time will benefit crop production and quality.

Accurate irrigation scheduling is also necessary for maximising the fertiliser usage of waxflower plants. Getting it right has tremendous benefits in terms of stem length, plant health, flower quality and management of the environment.

Current scheduling methods combine data from accumulated experience with modern technology—matching irrigation to plant needs and the water holding capacity of the soil (Figure 6.1).

Correct irrigation scheduling depends on an understanding of:

- soil type
- farm location or climate
- plant growth stage
- plant size and timing of pruning
- variety
- water quality and irrigation system performance.

There are two main ways to schedule irrigation:

A. Evaporation replacement
which relies on local experience, or

B. Soil moisture monitoring using:

- tensiometers
- EnviroSCAN® and Time Domain Reflectometry (TDRs) which enable monitoring of water use by plants on a real time basis.

Both techniques (A and B) are outlined in this chapter, but fine-tuning these techniques on your own property is important to achieve best results.

A. Evaporation replacement

Water use rates depend on weather conditions. This can be determined from:

- current weather
- historical evaporation data
- grower experience of past scheduling.

Crop factor

Waxflowers and all other crops, use water as a percentage of the evaporation from a free water surface. Free water evaporation can be measured by an evaporimeter in your crop (see Farmnote 22/90 to construct your own evaporimeter).

Evaporation replacement calculates the amount of irrigation required based on a percentage of the evaporation rate. The percentage used is called the **crop factor**. Crop factors:

- vary between plants
- are adjusted for irrigation method, plant size and growth stage.

Recent research work has determined the crop factors for waxflowers. When using drip irrigation on mature waxflower plants in the south-west of Western Australia evaporation replacement varies 50–75 per cent—calculated as from the daily evaporation for that site.

To set irrigation programs you can predict water requirements for a location using evaporation rates from the previous week, or by using the daily evaporation rates for a location from long-term averages (see Bureau of Meteorology website **www.bom.gov.au**). Not all locations have weather records, so you may estimate evaporation rates using data from the nearest Bureau of Meteorology site, or keep evaporation records for your own property.

Other sources of evaporation rates for your calculations include:

- radio broadcasts of daily evaporation rates in some areas
- published long-term evaporation figures (see Department of Agriculture Resource Management Technical Report 65)
- DAFWA weather website **www.agric.wa.gov.au/climate** which includes live and historical data with links to other weather websites.

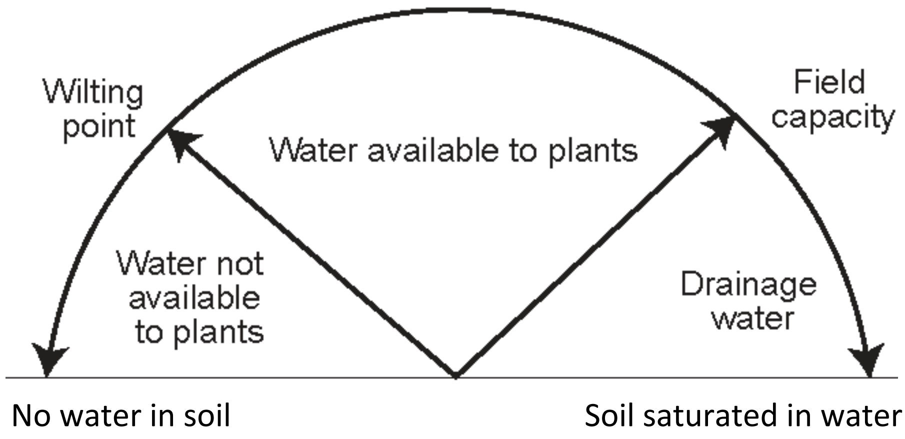


Figure 6.1. Relationship between moisture levels in the soil showing the total water available for use by the waxflower plant

Calculating crop water needs

For plants that do not have overlapping canopies, this formula is used to calculate water requirement. It is based on the area the plant canopy covers.

For example: Calculate the water requirement of a waxflower plant, in January near Gingin, with a canopy circular in shape and 1.5 m across (0.75 m radius). The plant is irrigated with two 4 L/h drippers. Assume the average daily evaporation in January is 9.0 mm/day *(use the current figure for the region in which the waxflower is being grown, Table 6.1)* and the crop factor for waxflower is 0.75.

Table 6.1. Average evaporation for districts in Western Australia for January

District	Evaporation per month (mm)	Evaporation per day (mm)
Albany	225	7.2
Perth	260	8.4
Geraldton	300	9.7
Northampton	335	10.8

Volume of irrigation per plant (L/day)

= mm evaporation x canopy area x crop factor

= pan evaporation x 3.142 x (crop diameter)^2 x crop factor

= 9.0 mm/day x (3.142 x 0.75 x 0.75) m^2 x 0.75

***Irrigation* per plant** 11.9 L/day.

Logistics of supplying water

To calculate how long drippers must be operating to supply each plant with this amount of water: with two drippers per plant supply 4.0 L/h each giving a total of 8.0 L/plant/h.

Hours of irrigation per plant (h/day):

= Quantity required (L/day) / Sprinkler or dripper flow (L/h)

= 11.9 L/day / 8.0 L/h

Irrigation must run for 1.49 hours each day (rounds up to 1.5 h/day).

Irrigation may need to be increased if the site is very weedy or a cover crop is present (they also use water). If the water is saline you will need to allow for a leaching factor. Decrease the amount of irrigation if significant rainfall occurs.

To calculate irrigation frequency

Determining your soil type and root zone

Knowing your soil types and the effective rooting depth of your crop is a good starting point to plan irrigation strategies. In young plantings, ideally you should design your irrigation system so you can:

- irrigate varieties with different water requirements together
- irrigate different soil types within your flower farm independently.

Heavier soil types require less frequent irrigation as they are capable of storing more water. Sandier soils, such as coastal sands, require more frequent irrigation than heavier soils.

In addition, different soils give up their water in different ways. Plants require energy to extract water from soils. They are able to extract more water from a clay or loamy soil than a sandy soil.

The amount of water that can be easily extracted by a plant from the root zone is called **readily available water or RAW** (see Table 6.2). This is the amount of water stored in the soil pores after water has freely drained out of the profile (field capacity) and where water is readily extracted by the plant (above the wilting point). It is about 20 per cent of the stored water for a loamy sand, 60 per cent for a loam.

Table 6.2. Readily available water (RAW) for different soil types

Soil type	Readily available water (RAW) mm/m of soil (using 50% depletion)
Coastal plain sands	20
Loamy sand	35
Sandy loam	50
Loam	60
Clay loam	70
Clay	60

Sandy soils not only store less water, but less of that stored water is available to the plant. This means that plants can quickly use up all stored water and therefore proper scheduling of irrigation is critical to avoid stressing the plant and maximising yield. Using a tensiometer helps to determine if the crop is stressed.

The effective root depth from which the plants can extract water also affects the readily available supply. On heavier soil types about 90 per cent of the roots of native plants are within 60 cm of the surface. On sandy soils this depth may be halved. On some duplex soils (for example, sand over clay) where rooting depth is restricted, it may only be 20 cm, and have complications such as a perched watertable.

You need to know your soil type and its profile at depth to design an effective irrigation system. A soil survey is an accurate way to determine the soil types on your property.

To a certain extent the effective rooting depth can also be modified by irrigation practice. Cutting-grown plants do not have a taproot and, when irrigated regularly, the root ball tends to stay relatively close to the surface where aeration and soil moisture content are optimal. Digging metre deep survey pits will allow you to determine effective rooting depth.

The aim of any irrigation schedule is to keep the amount of water in the root zone in the range where it is readily available to the plant.

Example continued

For the situation described in calculating crop water needs, we can work out the amount of water in litres each plant can access.

Although we have a mature plant with 80 per cent of its roots in the top 30 cm it is more likely that roots will extract water from deeper in the soil profile (50 cm).

Each of the drippers has a wetting pattern which is 50 cm across at its widest point. The soil RAW is 20 (Table 6.2).

The ideal situation is to start replacing water as soon as 4 L is used. The plant in the example uses 11.9 L per day so we are going to have to irrigate three times a day and this is not practical. Twice-daily watering in this instance is more practical even though some water will be lost due to leaching.

The problem with any calculation based on historical data is that it is does not show you what is actually happening from day to day.

The risk is that in hot weather or during a heatwave, the plant may not get the water it actually needs and become stressed.

Current evaporation figures are available on the Bureau of Meteorology website (www.bom.gov.au) and can be used to calculate irrigation needs.

To calculate the area of the wetting pattern use the formula below:

Area per dripper	=	πr^2, where r = radius of the wetted area ($\pi = 3.142$)
	=	3.142 x 0.25 x 0.25 = 0.2 m^2
Total wetted area	=	0.2 m^2 x 2 drippers = **0.40** m^2

Next step is to calculate the plant available water in the root zone:

Volume of water available in litres per plant	=	wetted area (m^2) x root depth x RAW
	=	0.4 m^2 x 0.5 m x **20 mm/m** (Table 6.1)
	=	**4 L** available water that can be stored in the soil

To calculate the irrigation interval:

Irrigation interval (days)	=	$\frac{\text{Available volume of water in root zone (L)}}{\text{Daily plant use (L/day)}}$
	=	$\frac{4.0\ \text{L}}{11.9\ \text{L/day}}$
	=	**0.34** days or **3** times per day

This means that the soil can hold only 4 L of water in the root zone below the crop—any additional water added will simply drain away below the root zone.

Splitting irrigation applications into three sessions—adding one-third of the daily irrigation requirement at a time—will overcome this.

Seasonal irrigation requirements

Irrigation requirements for waxflower plants vary seasonally (Figure 6.2). This depends on evaporative demand, rainfall, crop growth stage and management.

In Western Australia, after flowering, demand rapidly increases from October through to February as both stem length and evaporative demand increase.

Irrigation requirements taper off after April with the onset of cooler weather and shorter days. By May irrigation is cut back to prevent on-growth during budding. Irrigation may be still necessary if the break of season has not occurred and clear days persist.

Amount of water required

Examples from Western Australia show that the amount of irrigation required during the middle of summer can vary from 5 to 15 L/plant generally from Perth to Northampton.

On-line crop calculator programs

Irrigation needs per crop can also be determine using the Crop Calculator (*Irricalc*) found at **http://calc.winstage.bbhost.com.au**

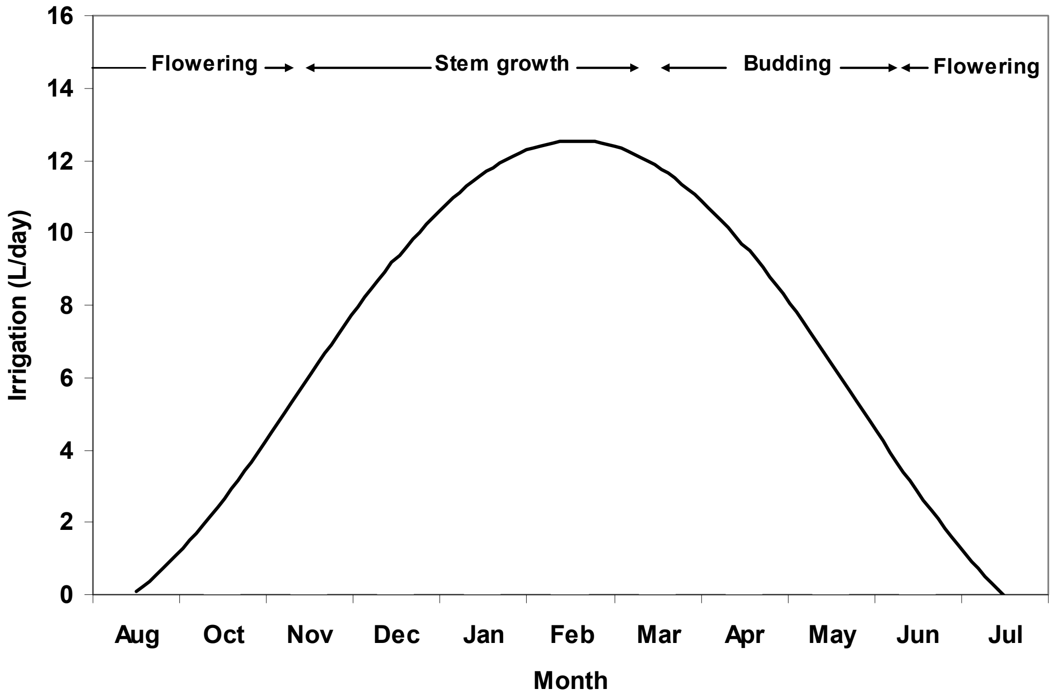


Figure 6.2. Seasonal irrigation requirements for a waxflower crop

B. Soil moisture monitoring

Many soil moisture sensors are available commercially, including tensiometers, gypsum blocks and capacitance probes. See Farmnote 26/90 *Soil moisture monitoring equipment*.

The most suitable tool will depend on your situation. Accuracy, simplicity, cost, labour and soil type will help you choose the most suitable. Only tensiometers are discussed in this section because they are reliable, low cost and easy to install.

Tensiometers

Tensiometers are commonly used to assess soil moisture and suitable irrigation periods. They are read in centibars (cBars) or kilopascals (kPa).

Note: Kilopascals (kPa) are a metric measure of pressure. The empirical unit of pressure is centibars (cBars). kPa is equivalent to cBars.

Tensiometers can be read in negative kilopascals (–kPa) or centibars (cBars) which indicate suction as opposed to pressure (kPa).

Tensiometers can be purchased at most large irrigation suppliers.

Several types are available. Some are ideal for sandy soils (0 to 40 cBars) and others more suited to heavier soils (0 to 100 cBars).

Using tensiometers to check accuracy of irrigation scheduling

Soil moisture readings can be used to check if the evaporation replacement method is accurate.

Tensiometers are placed at an angle in the soil, under the plant (Figure 6.3). Graphing daily readings shows how moist the soil is, indicating any adjustments that need to be made to the scheduling.

Figure 6.3. Tensiometers monitor soil moisture under a Pearlflower bush at 15, 30 and 60 cm

Scheduling irrigation on evaporative demand for Laura Mae Pearl⦶ shows how soil moisture can be maintained (in this case between 0 and –13 cBars) by timing. Figure 6.4 shows a total of 8 L of water applied. This was split into two 4 L irrigation runs in a day, but only applied every second day (19, 21 and 23 March). In addition, 29 mm of rainfall fell on 22 March. Following irrigation, the soil dries during the day with plant evapotranspiration and then recovers following irrigation or rain.

This indicates that roots were located down to 30 cm in the soil profile. Irrigation is applied to return the tensiometer back to wet. This required 4 mm and 6 mm of irrigation water for 1–1.5 h of irrigation.

Scheduling using tensiometers

Two tensiometers, the shallower one placed in the root zone and the other just below the root zone (about 60 cm) can be used to schedule irrigation. Soil pits should be dug to determine the depth of plant roots.

Determining field capacity

The best time to do this is in winter directly after a period of heavy rain. The reading on the shallow tensiometer at this time corresponds to field capacity.

The irrigation requirements of waxflowers change with the season and the stage of the plant—actively growing or in flower (see Figure 6.2).

When to start irrigation

This should occur before plants become stressed. Plant stress starts when the plants have extracted all the available water from the soil.

The purpose of the shallow tensiometer is to indicate when plant stress is likely to commence and when to start irrigation.

The tensiometer readings at which irrigation should commence will vary with soil type.

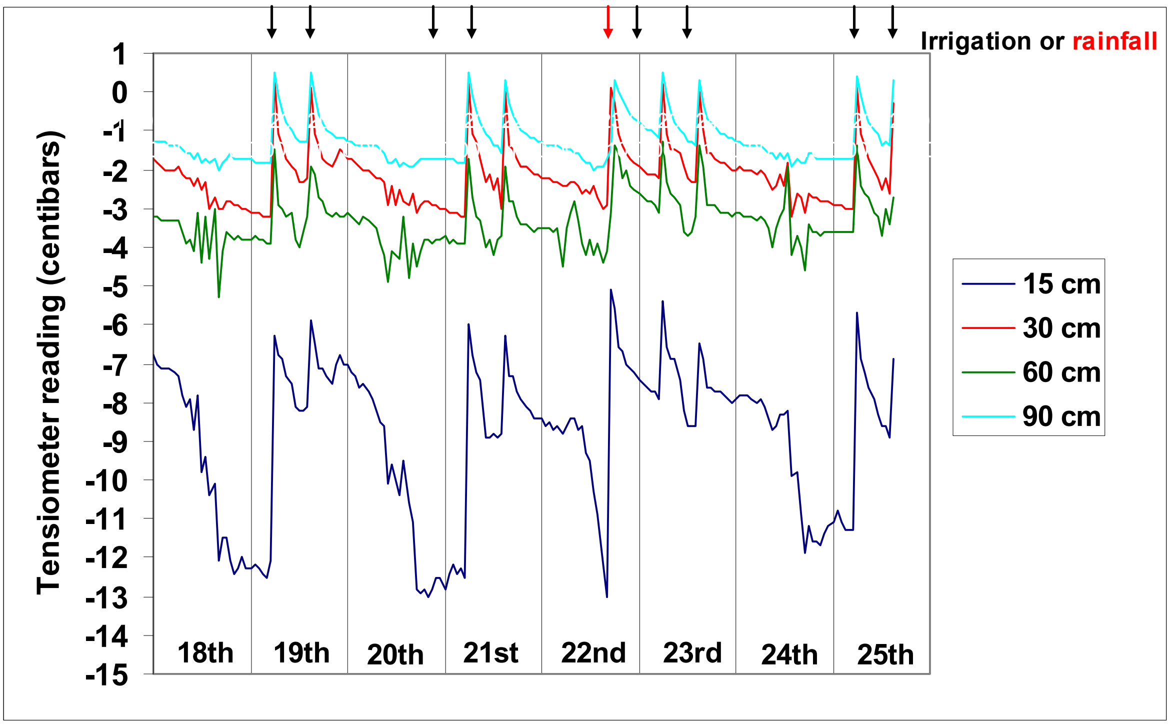


Figure 6.4. Irrigation scheduling for Laura Mae Pearl⦶ 18–25 March 2010 at Medina Research Station. Indicated are tensiometer readings at 15, 30, 60 and 90 cm depth with irrigation (black downward arrows) and rainfall (red downward arrows) events

In sandy soils, the upper limit should be 8 cBars. More loamy soils may be allowed to go up to 20 cBars and heavy clays to 40 cBars (see Table 6.3). These limits are approximate only and will vary with crop and exact soil type.

Table 6.3. Upper limits for shallow tensiometer readings to avoid plant stress

Soil type	Tensiometer readings (cBars)*
Light (sands)	8
Medium sandy loam to loam	25
Heavy clay loams to clays	40

** measured at start of irrigation*

How much to irrigate

The amount of irrigation to apply should be sufficient to lower the shallow tensiometer reading to field capacity.

If the field capacity figure is not reached, insufficient water is being applied. If the reading in the top tensiometer stays below the value of field capacity then you are over-watering and problems such as root rots due to waterlogging can occur.

Efficient irrigation aims to keep the tensiometer readings between field capacity and the stress point.

As summer progresses the deeper tensiometer may show the soil is starting to dry out. If adequate moisture in the root zone is maintained, it should not create a problem.

When to turn off the irrigation

The deep tensiometer readings are used to indicate over-watering. If the readings remain at field capacity then the crops are being over-watered.

Graphing tensiometer readings, rainfall and the amount of irrigation applied, regularly will assist you to fine-tune your irrigation scheduling. Remember that the true reading is obtained by correcting for depth by subtracting 1 cBar per 10 cm of tensiometer length.

For example, a 15 cm tensiometer reading of 6 cBars must have 1.5 cBars subtracted from the reading. So the actual reading is 6 – 1.5 = 4.5 cBars.

For a 30 cm tensiometer, subtract 3 cBars. This correction is to allow for the suction force needed to support the column of water.

Irrigation inefficiency

Fluctuating irrigation operating pressures, poor design and maintenance may all affect the efficiency of your irrigation system.

You may need to add 15–30 per cent extra water to the soil surface to compensate. Check irrigation outputs before and during the growing season to determine if the extra application is necessary. With pressure regulated emitters, problems may be reduced.

Irrigation control systems

Demand irrigation

The basis of this system is a soil moisture sensing device, usually a tensiometer fitted with a pressure sensitive electric switch and hard-wired to the irrigation controller. Irrigation is automatically scheduled via predetermined parameters set to the tensiometer electrical resistance connections. As moisture levels drop to target levels, the tensiometer triggers the irrigation pump to commence watering.

Remote sensing

This is a sophisticated computer control system, using numerous sensing devices to determine on-site soil moisture levels. The system can be either hard-wired or utilise small radio transmitter communication to and from the computer. The system charts all parameters and automatically schedules watering.

Further reading

Department of Agriculture and Food, Western Australia:

- Farmnote 333 (2009) *Selecting the right pump for an irrigation system.*
- Farmnote 332 (2009) *Different pumps for irrigation systems.*
- Farmnote 276 *What should I use to measure soil moisture?*
- Farmnote 234 (2007) *Water salinity and plant irrigation.*
- Farmnote 198 (2007) *Calculating readily available water.*
- Farmnote 196 (2007) *Converting readily available water (m) to litres for drip systems.*
- Farmnote 68/2004 *Tensiometers—preparation and installation.*
- Farmnote 3/2002 *Irrigation of native flowers in Western Australia.*
- Farmnote 79/94 *Soil moisture sensors for sandy soils.*
- Farmnote 48/92 *Efficiency of sprinkler irrigation systems.*
- Farmnote 41/90 *Blockages in irrigation lines.*
- Farmnote 35/90 *Evaluating sprinkler and trickle irrigation systems.*
- Farmnote 26/90 *Soil moisture monitoring equipment.*
- Farmnote 24/90 *Interpreting tensiometer readings.*
- Farmnote 23/90 *Irrigation scheduling—how and why.*
- Farmnote 22/90 *Scheduling for trickle, sprinkler and flood irrigation.*
- Resource Management Technical Report 125 (1994) *Crop irrigation requirement program.*
- Resource Management Technical Report 65 (1988). *Evaporation data for Western Australia*.
- Irrigation requirements calculator available on the DAFWA website at **www.agric.wa.gov.au** —search for ‘irrigation requirements calculator’.

Rural Industries Research and Development Corporation:

- Publication 08/016 *Nutrient Management of Waxflower for quality and yield under adequate irrigation levels.*

7. Fertilisers and nutrition for premium quality waxflowers

Nutrition essentials

Waxflower requires:

- balanced fertilisers (kg/ha/y):

nitrogen (N)	150
potassium (K)	115
phosphorus (P)	7
calcium (Ca)	8
magnesium (Mg)	6
sulphur (S)	10
trace elements	0.2

- small fertiliser doses delivered often
- varying amounts of fertiliser according to season, age of plants and plant density.

Fertiliser application by:

- fertigation through drippers (best)
- topdressing (depends on rainfall).

Soil pH can affect nutrient uptake:

- high pH (>7) can tie up iron, manganese, copper and zinc
- low pH (<5) can tie up phosphorus, calcium and magnesium.

Calculate amount of fertiliser required per hectare according to:

- age of plants
- varietal requirements
- planting densities.

Nutrient sampling can help fine-tune your fertiliser regime:

- monitor nutrient status of your soil:
  - soil test (especially P levels)
  - soil pH (ideally 5.5 to 6.5).
- monitor nutrient status of your crop:
  - check leaf colour
  - tissue test young leaves after summer growth.

Make up a stock tank for fertigation to:

- supply a given number of plants
- cater for seasonal requirements.

Adjust injection rates amounts and timing according to:

- varietal requirements
- age of plants
- season
- soil type.

Waxflower responds well to balanced fertilisers applied at moderate rates. Having a suitable fertiliser program is essential to producing stems that are of sufficient length and the right thickness with quality flowers. Correct nutrition also plays a role in making plants more resistant to insects and diseases.

It is essential when designing a fertiliser program for waxflower to also have in place an efficient irrigation system delivering adequate water; this way production is maximised.

Growers face many choices as to which fertiliser to use and how to apply it. There are many types of fertiliser sold in Australia. These include inorganic, quick release, slow release, single element or complete fertilisers, which can be in solid, liquid and organic forms.

There are two main ways to fertilise waxflower plants:

- fertigation—where readily soluble fertilisers are injected through irrigation lines.
- topdressing—where solid or granulated fertilisers are applied in several (split) applications a year

Fertilisers are also sometimes applied as a foliar spray although this is usually to correct a specific deficiency and is an expensive way to fertilise plants.

Fertigation

Fertigation is the technique of applying soluble fertilisers to crops through micro-sprayers, trickle or ‘t-tape’. **Fertigation is the preferred system of applying nutrients to waxflower.**

Size of tank

To work out the size of tank for fertigation, you need to work out the amount of each fertiliser that will be applied for each area.

The size of the tank is determined by the solubility of the least soluble fertiliser.

This can be seen in the following example for one hectare, where urea is the most soluble fertiliser and potassium sulphate is the least soluble. The use of potassium sulphate determines that the size of the tank should be 730 or 1000 L to allow for lower solubility in cold weather.

Fertiliser injection methods

It is important to select a fertiliser injection method that best suits your irrigation system and the crop to be grown. Each fertiliser injector is designed for a specified pressure and flow range. Injection methods include metering pumps, pressure differential and venturi (vacuum).

Metering pumps use a pump to inject the fertiliser solution from a supply tank into the mainline. The metering pump may be driven by an electric or diesel motor or by water pressure.

Pressure differential is created through the use of a regulating valve between the tank inlet and outlet causing water to flow through the tank (containing the fertiliser mix). This can be achieved either by placing a bag containing the fertiliser solution placed in the tank and allowing the water pressure to force the solution out and into the system, or by allowing water to enter the tank and mix with the fertiliser solution before flowing into the system.

A **venturi** is a device to create reduced pressure (vacuum) that sucks the fertiliser solution into the line. This system does not require external power—it relies on the flow of water through the irrigation line (see Figure 7.1).

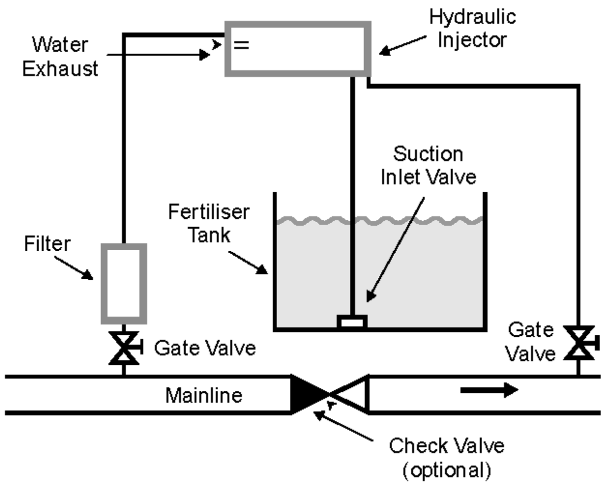


Figure 7.1. Venturi or vacuum fertiliser injector

Preparing fertilisers

When preparing fertiliser solutions for injection units, care must be taken with chemicals. Most materials used in fertigation are corrosive. Some fertilisers are incompatible, they may settle out and block the system, therefore do not mix:

- fertilisers containing calcium with sulphates or phosphates
- magnesium sulphate with mono ammonium phosphate
- calcium hypochlorite or sodium hypochlorite with nitrogen
- phosphoric acid with calcium or magnesium, or with copper, iron, manganese and zinc sulphates
- ammonium sulphate with potassium chloride.

The injector is also often used to inject acid into the irrigation system for regular maintenance—so all parts should be made of corrosion resistant materials.

If applying fertilisers through micro-sprinklers, run sprinklers for 2–5 minutes after fertigation to wash the fertilisers from the leaves and into the soil, and to clean out nozzles.

Apply fertiliser throughout the year. As summer is the main period of growth, it is important that nutrients are available to the plant at this time.

Nutrient levels of healthy young tissue during the active summer growth phase are around 1.25–2.5 per cent for nitrogen, 0.8–1.5 per cent for potassium and during flowering 0.1–0.2 per cent phosphorus. Reduce rates, especially nitrogen, after budding to minimise on-growth.

Calculating amount of fertiliser plants receive

To calculate how much of a nutrient you add to a fertigation tank you need to know how much nutrient an individual plant should get. Fertiliser rates are usually given as kg/ha.

Waxflower requirements (kg/ha/year):

Nitrogen (N) = 150
Potassium (K) = 115
Phosphorus (P) = 7
Calcium (Ca) = 8
Magnesium (Mg) = 6
Trace elements (usually supplied as a proprietary brand such as Librel BMX® or Fetrilon Combi®).

Convert this rate to a fertiliser formulation

This depends on chemical analysis of the fertiliser. For example, urea is a concentrated source of N with 46 per cent N, while mono-ammonium phosphate (MAP) is a high P source with 22 per cent P with low N (10 per cent).

Urea requirement per year (kg/ha/year):

= 101.2/0.46
= **220** kg/ha/year or 220,000 g/ha/year.

There will be other sources of N such as potassium nitrate which need to be added as fertiliser to account for total N received by plants.

Calculate the number of plants/ha

For Pearlflower at between-row plant spacings of 3 m and within-row plant spacings of 1.5 m:

Plants per hectare $= \frac{(10{,}000)}{(1.5 \times 3)}$
= **2222** plants/ha

Calculate individual plant requirements

Plant nutrient need $= \frac{220{,}000 \text{ g/ha/year}}{2222 \text{ plants/ha}}$

= **99** g urea/plant/summer.

To convert this to a daily basis divide by the number of days plants are irrigated

If plants are fertigated daily with urea from 1 October to 31 March (182 days).

Daily nutrient need $= \frac{99 \text{ g urea}}{182 \text{ days}}$

= **0.54** g urea/plant/day

Calculating how much fertiliser is needed to make up stock solution

Number of plants to be fertigated = 800
Number of days of fertigation = 20

Amount of urea to add to stock tank
= g/plant/day x number of plants x days
= 0.54 g/plant/day x 800 plants x 20 days
= 8.7 kg

Making up a stock solution

Size of stock tank is usually 100 or 200 L, which works well when no more than 20 kg of fertiliser is used.

Care needs to be taken when mixing fertilisers. For instance, calcium nitrate mixed with phosphates or sulphate can cause precipitation.

Solubility

The volume of water required to dissolve an amount of fertiliser depends on its solubility. At 20 °C, fertilisers (for example urea, ammonium sulphate, potassium sulphate, di-ammonium phosphate have a solubility in the range 0.32 kg/L (potassium nitrate) to 1.92 kg/L (ammonium nitrate) shown in Table 7.1.

When making up concentrated stock solutions, it can be helpful to know the solubility of the chemicals involved (Table 7.1). Divide the total amount of fertiliser you are going to use (listed in the fertiliser injection program) by the volume of stock solution to check that the amount does not exceed the solubility.

Table 7.1. Solubility of some fertilisers in water at 20 °C

Fertiliser	Solubility (kg/L)
Ammonium nitrate	1.920
Ammonium sulphate	0.754
Boric acid	0.049
Calcium nitrate	1.290
Di-ammonium phosphate	0.588
Magnesium sulphate	0.337
Mono-ammonium phosphate	0.374
Potassium chloride	0.342
Potassium nitrate	0.316
Potassium sulphate	0.111
Urea	1.080

Mixing

Fertilisers differ in the amounts that can be dissolved in water. Most fertilisers dissolve more readily in warm or hot water. Solutions should be made up fresh and in a thoroughly clean tank.

Remember, if a stock solution is heated to dissolve the components, the fertiliser may crystallise when the solution cools down. To avoid this, dilute the solution or use it immediately.

Setting the injection rate

Injector systems may allow a dial up dilution factor or may need calibration by hand to get the desired dilution rate.

Assume the size of the stock tank is 200 L and you have added 8.7 kg of urea (see above). If irrigation rate is 5 L/plant/day, that is, 1.25 hours irrigation using 4 L/h emitters:

For 800 plants:

= 4 L/h x 1.25 h x 800 plants
= 4000 L/day irrigation water

Since this example is required to supply 0.435 kg urea to 800 plants/day (0.05 of a full tank), that is 10 L of stock solution calculated above.

$$\text{Dilution factor in irrigation} = \frac{4000\text{ L}}{10\text{ L}}$$

$$= \mathbf{1:400}$$

Tissue testing

The optimum level of nutrients required by the plant (Figure 7.2) can be checked by sampling the top 7–10 cm of new leaf growth. The best time to take these leaf samples, is after active shoot growth and before buds appear at the end of summer.

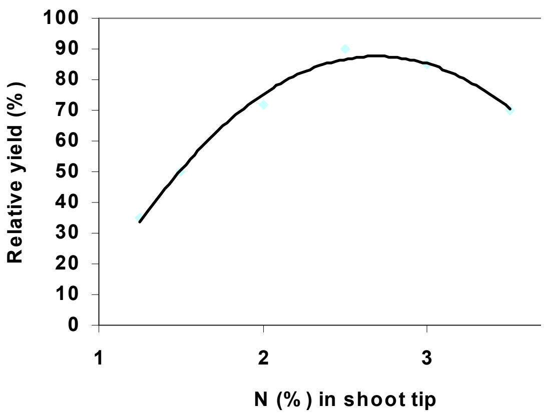


Figure 7.2. Optimum nitrogen levels in shoots to give maximum yield

Nutrient sampling

Tissue and soil sampling is useful for determining the effectiveness of your fertiliser program.

Soil pH

Soil pH can affect the availability of a nutrient, particularly trace elements. For example, in alkaline or high pH soils, iron (Fe) becomes unavailable. Soil pH can become acidic with application of ammonium fertilisers. Alternating with calcium-based fertilisers such as calcium nitrate may be necessary.

Nutrient deficiency colour chart

Table 7.2. Leaf tissue nutrient percentages required for waxflower and deficiency symptoms

Nutrient	Optimum range	Deficiency description	Deficiency symptom
Nitrogen (N)	1.50–2.20%	Reddening of leaf tip and yellow or red-purple green younger leaves in low level deficiency to yellowing of entire leaf in severe cases	
Phosphorus (P)	0.12–0.19%	Yellow-green to bronze ends of older leaves	
Potassium (K)	0.70–1.50%	Orange-green older leaves	
Calcium (Ca)	0.45–0.80%	Orange to reddening of older leaves with dark red patches	
Magnesium (Mg)	0.18–0.25%	Red-yellow older leaves	
Sulphur (S)	0.12–0.24%	Chlorosis of leaves	
Trace element	**Optimum range**	**Deficiency description**	**Deficiency symptom**
Copper (Cu)	4–7 ppm	Orange-green or green-yellow older leaves	
Zinc (Zn)	15–18 ppm	Gold-green older leaves	
Iron (Fe)	80–120 ppm	Yellow or orange-yellow (chlorotic) older or younger leaves	
Manganese (Mn)	20–40 ppm	Red-burgundy older leaves	
Boron (B)	25–35 ppm	Red older leaves	
Cobalt (Co)	<0.2 ppm	Dark green to grey older leaves	

Fertigation injection program for new plantings

Fertiliser programs vary from summer to winter (see Table 7.3).

Acclimatise young plantings to the fertiliser program by increasing the frequency of injection gradually.

Initially inject fertilisers one day per week at above rates for first month, then one day every three days for two weeks increasing frequency until plants are fertigated daily.

Specific ratios for the main nutrients for waxflower are:

- N 1
- P 0.045
- K 0.750
- Ca 0.056
- Mg 0.037
- S 0.024
- Fe 0.0014

Topdressing

While the easiest and cheapest way of fertilising plants is to topdress or broadcast fertilisers along planting rows, it is not the preferred method as it requires rainfall to wash the fertiliser into the root zone before that fertiliser becomes available.

In Western Australia on sandy soils, unless irrigation is available, topdressed fertiliser during the spring–summer months may not get to the plant until autumn when it rains.

Fertiliser broadcast onto sandy soil during the wetter months can be lost by washing past the root zone. In recent times the availability of a number of slow release formulations can overcome this leaching problem.

Splitting fertilisers into several smaller applications can save wastage.

Pollution

Over-fertilising can lead to salinity, acidification and nitrification of soils and leaching into watercourses.

Caution: Be careful when mixing phosphoric acid. Add the acid to the water and not the water to the acid, as the acid will boil and spit.

Note: It is the responsibility of the user to ensure all safety precautions are taken when handling and dispensing fertilisers for the operator and people associated with this process. Fertiliser requirements may vary with variety of waxflower being grown. All new mixes should be applied to test plants before general use.

Table 7.3. Seasonal fertiliser program for waxflowers

Fertiliser	**Summer rates (Oct–Mar)**	**Early autumn and spring rates (Apr–May, Aug–Sept)**	**Winter rates (Jun–Jul)**
Urea	8.70	0	0
Potassium nitrate	10.20	4.70	0
Calcium nitrate or magnesium sulphate	0.80	2.30	0.90
Mono-ammonium phosphate	1.10	0.32	0.22
Potassium sulphate	0	0	0.85
Trace (Librel®)	0.20	0.10	0.04

Note: Calcium nitrate or magnesium sulphate can cause precipitation.

Make up fertilisers as a 200 L stock solution and inject 10 L of this per 800 plants being watered.

Table 7.4. Commonly used fertiliser materials and analysis of important elements

Fertiliser	Chemical	%N	%P	%K	% other
Ammonium sulphate	$(NH_4)_2SO_4$	21.0			
Borax (di-sodium tetraborate decahydrate)	$Na_2B_40_7.1OH_2O$				11% boron
Boric acid	H_3BO_3				17% boron
Calcium nitrate	$Ca(NO_3)_2$	15.5			19% calcium
Copper sulphate	$CuSO_4.5H_20$				25% copper
Copper chelate	$Na_2CuEDTA$				13% copper
	NaCuHEDTA				9% copper
Di-ammonium phosphate	$(NH_4)_2HPO_4$	21.0	23.0		
Di-potassium phosphate	K_2HPO_4		17.7	45.0	
Ferric sulphate	$Fe_2(SO_4)_3.4H_20$				23% iron
Ferrous sulphate	$FeSO_4.7H_20$				19% iron
Iron chelate	NaFeEDTA				5–14% iron
	NaFeEDDHA				10% iron
Magnesium sulphate	$MgSO_4.7H_20$				10% magnesium
Manganese sulphate	$MnSO_4.H_20$				25.5% manganese
Mono-ammonium phosphate	$(NH_4)H_2PO_4$	12.0	27.0		
Mono-potassium phosphate	KH_2PO_4		22.0	28.0	
Phosphoric acid (85%)	H_3PO_4		26.8		
Potassium chloride	KCl			50.0	
Potassium nitrate	KNO_3	13.9		38.6	
Potassium sulphate	K_2SO_4			41.5	
Sodium molybdate	$Na_2MoO_4.2H_20$				39% molybdenum
Urea	$CO(NH_2)_2$	46.6			
Urea plus ammonium nitrate (Spurt-N)	NH_4NO_3 + $CO(NH_2)_2$	32.0			
Zinc chelate	$Na_2ZnEDTA$				14% zinc
	NaZnHEDTA				9% zinc
Zinc sulphate	$ZnSO_4.H_20$				36% zinc

Note: The percentages listed above are those usually found in purchased horticultural grade product and so may differ from the theoretical percentage. Potassium chloride is not recommended for use in liquid feeds.

Further reading

Department of Agriculture and Food, Western Australia:

- Farmnote 301 (2008) *Preparation of liquid fertiliser stock solutions*.
- Farmnote 59/2003 *Fertilisers for waxflower production.*
- Farmnote 35/2001 *Selection of fertigation equipment*.
- Bulletin 4512 *Fertigation of vegetables in Western Australia*.

Rural Industries Research and Development Corporation:

- Publication 08/016 Nutrient management of waxflower for quality and yield under adequate irrigation levels.

8. Insect control for waxflower crops

Insect control essentials

Biosecurity—inspect all plant material entering the property for signs of insects.

Monitor your crop regularly in the field:

- highest risk September to March
- set up sticky traps
- sample flowers in the field.

Implement integrated field control followed by postharvest disinfestation treatments.

Maintain crop hygiene by removing infected plant material from around base of plants after harvest and pruning.

Insects in waxflower crops can cause feeding damage to flowers, leaves and stems (ringbarking weevil) or cause galls to form. Insects can also increase the risk of disease (for example the exudates from scale insects promote fungal growth).

A variety of native insects is attracted to waxflowers as a source of nectar. While many native insects are found on flowers, waxflowers may also be attractive to exotic insects from nearby horticultural and agricultural crops.

While these insects may not cause damage to flowers, if they are present in overseas consignments they can pose a quarantine risk in certain countries, such as Japan and the United States.

Types of insects found on waxflowers

A wide range of native insects is found on waxflowers (see Table 8.1), the most common are thrips (with seven species identified) and beetles (see Figure 8.1).

Figure 8.1. Scarab beetle on waxflower

Table 8.1. Key to damage caused by insect pests of waxflowers

Site of attack	Damage	Insect responsible
Above ground level	Leaves chewed	Beetles (nititulid beetle, nectar scarab beetle, jewel beetle) weevils, caterpillars (leaf tip webbing larvae), grasshoppers
	Leaves 'silvered'	Thrips (plague thrips, eucalyptus thrips)
	Leaves shrivelled, sucking damage to foliage, spots on leaves	Leafhoppers, scale insects, sucking bugs
	Growths on stems or leaves	Gall insects (gall wasp)
	Leaves 'webbed' together	Caterpillars (leaf tip webbing larvae)
	Flowers withered, distorted	Thrips (plague thrips, eucalyptus thrips), mites
	Stem hollowed out, stem death	Longicorn beetle
At ground level	Stem of waxflower 'ringbarked' just under surface of soil	Ringbarking weevil
Below ground level	Stem hollowed out; tunnels in stem	Termites

Insects affect flowers in four ways; they may:

- kill plants—for example the ringbarking weevil girdles plants just below the soil surface
- chew and damage flowers—the nititulid beetle larvae scars the surface of the flower receptacles
- chew and damage stems and leaves—the webbing moth leaf tipping larvae chews out leaf tips and sticks them together causing branching; the longicorn beetle hollows out stems causing them to die; and gall wasps cause swelling and distortion of stems and leaves
- pose quarantine risk if present on flowers at certain export destinations—for example, thrips, beetles and the light brown apple moth. Gall wasp larvae form a gall or swelling on leaves and stems announcing the presence of an insect, and this can also pose a quarantine threat.

Beetles, such as the flower beetle, can be present during the whole of the flowering season, while others appear en masse at one time. For example, the flower scarab beetle appears in early October in Western Australia, infesting the later flowering wax varieties. Therefore different control strategies are required for each of these beetles.

Field control programs

Three approaches are used to manage insects on waxflowers:

Crisis approach—an insecticide spraying program is used to control an insect infestation as soon as the first signs of damage are observed. For example, for control of ring barking weevil infestations, the soil and root system must be treated by injecting an appropriate insecticide.

Preventative approach—a regular spraying program is used to prevent insects from becoming established, often required at a specific time of year. For example, to control waxflower leaf webbing moth larvae, preventative spraying needs to start during the autumn months. It is too late once the moth has laid its eggs and the larvae has hatched out and started to eat leaves.

Integrated pest management (IPM)—insects are identified and insect activity on flowers is monitored, spraying only if numbers are sufficiently high. Insect numbers should be managed in the field so that postharvest disinfestation systems can control any residual insects. Applying this approach to thrips involves monitoring numbers during the flowering season and spraying only when insects reach threshold levels (usually 10 per bunch).

As many native insects do not damage flowers but co-exist with them, there is no need to spray them while stems are growing or flowers are still opening and are not ready to be picked. Spraying needlessly can cause chemical resistance to build up, and may allow more aggressive insects to move into flowers by removing competitors or predator insects.

Insect monitoring

This can be done by sampling bunches of flowers and shaking them out over a white surface and estimating the number of insects present. This method also allows the type of insect to be identified, which will aid in selecting a suitable insecticide treatment to be used if necessary (see Farmnote 394).

The other approach is to install white sticky traps in the field and estimate insect numbers weekly or fortnightly. By keeping records of when numbers of insects rise it will be possible to estimate when spraying is necessary.

To determine the effectiveness of insect control after field spraying and postharvest treatments, flowers should be sampled estimating insect numbers per bunch.

Timing of insect control

In Western Australia, insect numbers are low from July to mid-September and then increase as the weather warms up.

Numbers tend to peak when surrounding pasture or crop dries off in mid-October, and insects migrate onto waxflowers seeking a food source (the oasis effect). The exact timing will depend on location. See Table 8.2 for a checklist of insect control.

Table 8.2. Insect control checklist

1.	Regularly check for small galls caused by the gall wasp and remove any infected branches.
2.	Check the base of stems just below the soil surface for ringbarking weevil damage and drench with insecticide if discovered.
3.	Regularly check for leaf tip webbing moth larvae from March onward and spray with a pyrethroid as required.
4.	From September onwards check insect numbers, particularly thrips. Once numbers exceed 10 per bunch spray weekly until stem harvesting is complete.
5.	Be on the lookout (particularly during October) for scarab beetle infestations and use knockdown insecticide to remove beetles before harvest.
6.	At pruning, remove and dispose of any gall affected stems from bushes to prevent re-infection by the wasp.

Thrips and **beetle** numbers increase in waxflowers as the weather warms up, peaking when surrounding pasture or crop dries off in mid-October and insects migrate. Varieties that flower later in mid-September to November are at highest risk of being infested with high numbers of thrips (Figure 8.2) and beetles (Figure 8.3).

Figure 8.2. Thrips

Figure 8.3. Nititulid beetle on a waxflower style

Leaf tip webbing larvae infestation in Western Australia occurs when there is fresh vegetative growth, particularly January to April, and will require regular spraying to prevent damage to stems.

Figure 8.4. Leaf tip webbing larva

Gall wasps appear more active through the autumn–winter period. Gall wasps are difficult to control once established and regular inspection of plants will be required early in the year, to remove any infected stems before they become well established in the plantation. However, certain varieties such as Pearlflowers and Gemflowers, appear resistant and these should be planted in gall-prone areas to minimise the risk.

Figure 8.5. Stem gall (left) and gall wasp (right)

Light brown apple moth (LBAM) *Epiphyas postvittana* are native to south-eastern Australia and was introduced into Western Australia in the 1960s. Although LBAM has a very wide host range in Western Australia, they are a sporadic pest of deciduous fruits and table grapes. There is no evidence that they cause damage in flower plantations.

Figure 8.6. Light brown apple moth

LBAM are about 1 cm in length with a wingspan of around 2 cm. The male is smaller than the female and has dark brown marks on the hind wings, while the female has a distinctive brown spot on the centre of the upper body.

Detection is best achieved by pheromone traps specific to LBAM.

Organic *Bacillus thuringiensis* and spinosad sprays can be effective against young larvae. Insecticides including synthetic pyrethroids may also be very effective.

Postharvest dipping may be effective in removal of eggs from foliage or killing any larvae that may be present in leaves.

Postharvest disinfestation following insect field control

The effectiveness and type of postharvest disinfestation method used depends on the type of insect and numbers of insects on flowers. With an effective field spraying program the insect load on flowers will be low. This will increase the success of the postharvest system.

Quarantine entry controls are very strict in Japan and the United States and it only takes one insect in a carton to cause rejection.

For insects with tough outer casings such as beetles, it may be necessary to remove the insects from flowers prior to postharvest disinfestation treatment. A dipping system with recirculating pump and filtration is also useful for flowers with beetles present, as it washes insects from the flowers. If an aerosol system is used, then field removal of beetles is necessary.

The four principles to follow when applying insecticide are:

- use the correct insecticide, with a wetting agent if required
- use the correct rate
- get good coverage
- apply at the right time, and repeat at appropriate intervals.

Most of the rates listed in Table 8.3 have been used successfully on other ornamentals.

However, because of the wide diversity of species being grown, adequate control in all situations cannot be guaranteed, so when using the insecticides listed, you do so at your own risk.

Read all safety and application directions on the label before applying any insecticides.

Further reading

Department of Agriculture and Food, Western Australia:

- Farmnote 395 (2009) *Pests of export wildflowers.*
- Farmnote 394 (2009) *Postharvest insect disinfestation treatments for cut flowers and foliage.*
- Farmnote 40/2003 *Insect control of waxflowers.*

Table 8.3. Recommended pesticides for control of pests on wildflower and proteas

Pest	Chemical	Examples of trade name	Insecticide (added to 100 L water)	Comments
Aphids (e.g. cowpea aphid)	dimethoate*	Rogor®	100 mL of 300 g/L	Systemic
	maldison	Malathion	100 mL of 500 g/L	Low toxicity to humans
	imidacloprid	Confidor®	25 mL of 200 g/L	Systemic
Adult beetles and weevils (e.g. catasarcus weevil)	carbaryl	Bugmaster®	200 g of 800 g/kg	
Caterpillars (e.g. native budworm)	carbaryl	Bugmaster®	150 g of 800 g/kg	
	endosulfan	Thiodan®	200 mL of 350 g/L	
	spinosad	Success™	20 mL of 240 g/L	Safe on beneficials
	permethrin	Ambush	20 mL of 500 g/L	Ambush may cause leaf burn on some species
	Bacillus thuringiensis	DiPel®	50 g of 16,000 IU	Biological insecticide, safe on beneficial insects but may not kill all types of caterpillars
Leafhopper and sucking bugs (e.g. Rutherglen bug)	endosulfan	Thiodan®	200 mL of 350 g/L	
	dimethoate*	Rogor®	100 mL of 300 g/L	Systemic
	maldison	Malathion	100 mL of 500 g/L	Low toxicity to humans
	carbaryl	Bugmaster®	200 g of 800 g/kg	
Thrips	dimethoate*	Rogor®	100 mL of 300 g/L	Systemic
	maldison	Malathion	100 mL of 500 g/L	Low toxicity to humans
	tau-fluvalinate	Mavrik®	20 mL of 240 g/L	
	endosulfan	Thiodan®	200 mL of 350 g/L	
Soft scale	imidacloprid	Confidor®	25 mL of 200 g/L	Systemic
Grasshoppers	carbaryl	Bugmaster®	175 g of 800 g/kg	
	maldison	Malathion	500 mL of 500 g/L	Low toxicity to humans
	maldison (bait)	Malathion (bait)	50 mL of 500 g/L (bait)	Mix bait in plastic bag in 1 kg bran, leave overnight, spread thoroughly
Weevil adults	carbaryl	Bugmaster®	200 g of 800 g/kg	Good control is difficult to achieve
Termites	chlorpyrifos	Chlorpyrifos	1 L of 500 g/L	Flood area of attack

Note: All the above chemicals are toxic to bees and most beneficial insects, with the exception of Success™ which has much lower toxicity to both.

** Dimethoate use is currently being reviewed by the Australian Pesticides and Veterinary Medicines Authority (APVMA). Please check registration status before using this chemical.*

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9. Diseases of waxflowers and their control

Disease control essentials

Biosecurity plan:
- prevent diseases entering your property on vehicles, machinery or plant material.

Crop hygiene:
- remove and destroy pruning waste.

Soil conditions:
- prevent waterlogging
- balance fertiliser applications (too high or too low can make plants more susceptible to disease).

Monitor your crop for signs of disease:
- foliar diseases:
  - *Botrytis*
  - powdery mildew
  - *Alternaria*.
- soil-borne diseases:
  - *Phytophthora*
  - *Rhizoctonia*
  - *Pythium*
  - nematodes
  - root and collar rot
  - *Armillaria*.

Diseases of waxflowers can limit growth (*Alternaria*), make stems bare (mildew) or even kill the plant (*Phytophthora*). They can also reduce stem and flower quality making them unacceptable for export.

Monitoring and control programs are necessary to manage potential diseases on waxflowers. Chemicals for control of plant diseases are constantly changing, and growers are advised to consult their adviser for the latest information.

Foliar diseases

Preventing foliar disease in waxflowers requires good air circulation through the plant canopy. This can be improved by the use of windbreaks, orienting the plant rows, increasing plant spacing and by pruning.

Growers using drip irrigation or micro-sprays can keep foliage dry and thereby minimise the spread of aerial spores at certain times of the year.

During periods of erratic wet and dry weather conditions it is difficult to maintain protective coatings of fungicide, even if conditions were initially favourable for spraying.

Botrytis (*Botrytis cinerea*)

Botrytis, commonly called grey mould, is a widespread problem, both in the field and after harvest.

Figure 9.1. Close-up of* Botrytis *infection in waxflowers

Figure 9.2. Bud drop may be the first indication of a* Botrytis cinerea *infection

Table 9.1. Management of common diseases of waxflowers

Disease	Cultural control (additional strategies)	Chemical control: Active ingredient	Chemical control: Trade name/s	Comments
Foliar diseases				
Botrytis	Adequate nutrition (N and P levels)	mancozeb thiophanate-methyl plus mancozeb iprodione chlorthalonil	Mancozeb Zyban® Rovral Aquaflo® Bravo®	Rotate chemical groups to avoid developing resistance
Powdery mildew (*Leveillula*)	Adequate nutrition (P levels) Crop rotation (avoid planting waxflower on infected sites for 2 years)	sulfur copper fungicide bupirimate fenarimol potassium-dihydrogen-orthophosphate	 Nimrod® Rubigan®	Rotate chemical groups to avoid developing resistance
Alternaria	Adequate nutrition (N levels)	chlorothalonil mancozeb	Bravo® Mancozeb	
Branch dieback (*Botryosphaeria*)	Hygiene at pruning and harvest Remove and destroy any dead or dying plant parts	**Insecticide** chlorpyrifos & dimethoate, with **Fungicide** thiophanate-methyl plus mancozeb	Chlorpyrifos & Dimethoate Zyban®	Treat pruning and harvest wounds with fungicide to prevent infection Combine insecticides with fungicides to reduce infection through insect damage
Soil-borne diseases				
Phytophthora	Avoidance is the best strategy. Maintain biosecurity (of plants, vehicles and machinery)	metham sodium (or methyl bromide) phosphonic acid	 Chemphos 400	Soil drench. Kills plants, remove infected plants and soil then apply drench Foliar spray at times of active root growth
Collar rot (*Rhizoctonia*)	Adequate nutrition (N levels) Ensure optimal soil drainage and wind protection	iprodione	Rovral®	
Root rot (*Pythium*)	Adequate nutrition (P levels) Ensure optimal pH, salinity, and soil drainage conditions	etridiazole propamocarb furalaxyl	Terrazole® Previcur® Fongarid®	Hard on small plants Expensive Expensive
Root and collar rot (*Cylindrocladium*)		thiophanate-methyl plus mancozeb	Zyban®	Soil drench
Armillaria	Deep-ripping, remove all root material, fallow	n/a	n/a	Test soil before you plant
Nematodes (*Meloidogyne* & *Pratylenchus* spp.)	Crop rotation (non-susceptible host) before planting waxflowers	fenamiphos	Nemacur®	For treatment in crop Soil sterilisation prior to planting waxflowers

Note: Do not use more than three consecutive sprays of a fungicide from one chemical group.

Symptoms of Botrytis

Flowers are more susceptible to *Botrytis* than other parts of the plant. Symptoms include pale to tan coloured lesions, usually starting in the centre of the flower (the fungus feeds on nectar). Also, grey fluffy mycelium may be present, especially under humid conditions. Leaves and stems can also become infected with botrytis with young shoots withering and dying (see Figure 9.1).

During export, usually during transport, flowers infected with botrytis produce ethylene gas which causes flower drop (see Figure 9.2).

Preventative field spraying and postharvest dips are necessary before export to kill the fungus in flowers. Although flowers may have no sign of infection at harvest, botrytis may be present and temperature fluctuations combined with high humidity during transport may promote infection.

Management of Botrytis

Good hygiene is crucial—remove plant debris which may carry disease (one infected leaf exposed to 45 minutes of rain can infect up to 32 m^2).

The use of mulches (as opposed to weed mat) creates an uneven surface below the plants, reducing the dispersal of spores and minimising disease spread.

Pruning and positioning to maintain airflow within the plant canopy, and allowing good light penetration into the lower canopy, will reduce infection rates, as infection occurs in high relative humidity (> 93 per cent) with free water.

Botrytis can also affect propagation of cuttings. In protected environments such as greenhouses, dehumidifiers work well to bring relative humidity below 85 per cent and fans circulate morning air preventing condensation on leaves. In propagation houses, night break lighting prevents spore germination (*Botrytis* spores require four hours of semi-darkness for germination and infection).

Powdery mildew

Wax hybrids have variable susceptibility to powdery mildew (*Leveillula taurica*). Many of the *C. megalopetalum* hybrids such as Blondie, Revelation and Madonna, and the *Verticordia plumosa* hybrids such as Eric John, Jasper⌽ and Paddy's Pink, are much more susceptible to mildew infection than *C. uncinatum* cultivars or *C. axillare* hybrids.

Figure 9.3. Symptoms of powdery mildew on waxflower leaves

Symptoms of powdery mildew

Symptoms appear to differ between states. In Queensland, there is little or no evidence of powdery growth on tissue surfaces—only banded chlorosis of the leaf and premature leaf drop. In Western Australia, powdery spores are commonly seen (Figure 9.3) combined with rapid leaf drop of older affected foliage. In that respect, it may be mistaken for *Alternaria*.

Powdery mildew can flourish under warm and dry conditions. Ideal conditions for disease development are night temperatures of about 15 °C and high relative humidity combined with day temperatures above 26.5 °C and low relative humidity of 40–70 per cent.

Powdery mildew spores do not require free water to germinate—however high humidity is required to start an infection.

Management of powdery mildew

The general principles of trying to avoid moisture on leaves for lengthy periods, and maintaining good airflow around plants, apply to powdery mildew control on waxflowers.

Powdery mildew is only able to grow on living plant tissue. When the infected plant part dies, the fungus dies with it unless special overwintering spores are formed.

***Alternaria* leaf and stem blights**
caused by *Alternaria alternata*

Alternaria leaf spots and stem and flower blights can affect a wide range of crops including waxflowers.

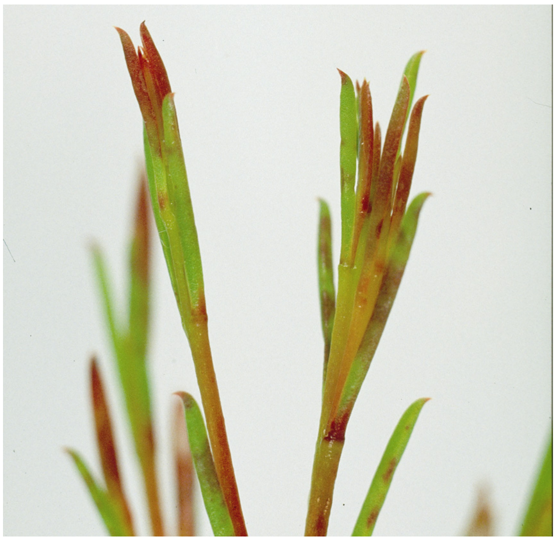


***Figure 9.4. Red blotches on leaves and stems are often the early signs of infection by* Alternaria**

Symptoms of Alternaria

Symptoms on wax are small necrotic lesions (1–2 mm) with a reddish border that occur on leaves and stems (Figure 9.4). In heavy infections, spots can join up and effectively ringbark the leaf or twig. Leaves that are bent over or dried off can indicate infection with *Alternaria*. Leaves may also drop off and stem tips may appear burnt and twiggy.

Flowers infected with *Alternaria* develop brown lesions, usually on the outer edges of the petals.

Management of Alternaria

Alternaria is spread through air-borne spores or water splash. Accordingly, it can be hard to control in rainy weather.

Branch dieback
caused by *Botryosphaeria*

Botryosphaeria is generally a weak pathogen that infects wounded or stressed plants and can also gain access through pruning cuts. The disease can cause cankers (lesions) and branch dieback that may eventually kill plants. The disease is often associated with insect wounds.

Studies with this fungus on protea showed that sporulation occurred from spring to late summer following rain, and was negligible during winter months despite abundant rainfall. Ideal conditions for infection include average daily temperatures above 20 °C combined with rainfall—also thought to be the case with waxflowers.

Management of branch dieback

The single most effective control measure is regular removal and destruction of all dead and dying plant parts.

Botryosphaeria infection can be prevented by maintaining high levels of hygiene in plantings, by reducing unnecessary wounding of plants, by treating harvesting and pruning wounds with a fungicidal spray and combining an insecticide with your fungicide.

Soil-borne diseases

The most common cause of death in waxflower is strangulation from root binding. The symptoms can mirror those of many other soil-borne diseases.

Phytophthora

The most common and widespread disease of waxflower is root and collar rot caused by *Phytophthora* species.

Waxflower is susceptible to attack by the same fungus that causes jarrah dieback, *Phytophthora cinnamomi*, and other species of *Phytophthora* such as *P. nicotianae* and *P. drechsleri/cryptogea*. *P. nicotianae* is the most common species of *Phytophthora* isolated from plantations and nursery stock.

Selections of waxflowers tolerant to *Phytophthora* have been made and may be used as rootstocks, but these are not widely available in all states.

Symptoms of Phytophthora

Early signs of infection are leaf yellowing and leaf drop. Plants usually die over a number of weeks, from the leaf tips back. Sometimes only one side of the plant is initially affected (Figure 9.5).

Figure 9.5. Early symptoms of* Phytophthora *on waxflower

Treatment of Phytophthora

The best treatment for *Phytophthora* is avoidance. When buying a property for flower production, it is a good idea to take samples and have both soil and water tested—either from areas of greater risk or the whole property—prior to purchase.

In heavier soils, examine the profile to ensure soil is free-draining as this will minimise the risk of disease in wet years.

If water is drawn from a source in contact with soil, such as a dam, soak or creek, then treating the water to remove *Phytophthora* (and *Pythium*) may be worthwhile. Chlorination or microfiltration are both effective, but the former is more suitable for treating large volumes of water without adverse effects on water pressure. Testing large bodies of water for the existence of *Phytophthora* is unreliable.

It is extremely important to buy plants from reputable, accredited nurseries in order to avoid bringing in the disease on plants. Similarly, avoid contaminating the site with soil carried in on vehicles, implements and footwear.

If *Phytophthora* is isolated from plants on the property, then there are two possibilities for control. One is suppression of the disease, the other is elimination.

Suppression: This is the most common method of dealing with *Phytophthora*. The chemical of choice is phosphorous (also known as phosphonic) acid), applied as a foliar spray during active root growth. The chemical needs to be regularly re-applied and should ideally be started before there is significant damage to plants.

Trials have shown that the more susceptible the cultivar, the higher the frequency of application required to keep plants in commercial production. Two waxflower varieties, a white and Lady Stephanie became non-commercial even with sprays at two-week intervals. Higher soil moisture levels also decrease spray efficacy.

The pathogen remains in the soil and may spread further.

Elimination: This is the more difficult option. It involves carefully removing infected plants, along with the soil from the root zone, and sterilising the area. These treatments are only effective to a depth of about 30–45 cm, so if the disease remains at depth, new plants may be infected when their roots grow deeper.

Collar rot
caused by *Rhizoctonia*

This disease is becoming more prevalent on waxflowers. *Rhizoctonia* is a weak pathogen, normally associated with stress (from waterlogging, wind damage or planting too deeply) at the collar region of the plant(see Figure 9.6). Sometimes, infection may come from the nursery or occasionally fungus may enter through insect damage.

***Figure 9.6. This dying waxflower plant shows discolouration around the collar region from* Rhizoctonia**

Treatment of Rhizoctonia

It is important to deal with both the disease and the underlying problem, so it may be necessary, for example, to improve soil drainage or create a windbreak. If planting waxflowers in heavier soils, consider mounding. Adequate shelter will reduce buffeting from wind.

Chemical treatment is only effective if applied in the early stages where the disease has not yet ringbarked the plant.

Root rot
caused by *Pythium*

Many species of *Pythium* cause root rot diseases. Some have a limited host range while others such as *Pythium ultimum,* have a very wide host range. *Pythium* is found in most cultivated soils, entering plant roots under waterlogged conditions, often where roots have been damaged by low pH or high salt levels.

Generally, *Pythium* affects seedlings or young plants. In mature woody plants, it is most common when very wet soil conditions predispose roots to attack.

Pythium usually gains entry to the root system via the young tissue of the root tips. It causes rapid rotting of the root system and occasionally the stem tissue.

If the soil dries and conditions become more favourable to the plant, new roots may be produced and the plant may recover or remain free of symptoms.

Under wet conditions such as poor soil drainage or excess irrigation, more roots are killed and the plant may wilt, stop growing, or even collapse and die.

Treatment of Pythium

To effectively control *Pythium*, any soil problems relating to pH, salinity and waterlogging must be resolved before chemical control methods are used.

Root and collar rot
caused by *Cylindrocladium* (*Calonectria)*

Cylindrocladium species infect a range of nursery plants, and while symptoms are the same as *Phytophthora,* the disease does not respond to phosphonic acid.

Cylindrocladium root rot has been found in waxflower crops in Queensland and is also common in potted and field culture in the eastern states. While it is not commonly found in Western Australia, it has been isolated from a *Chamelaucium uncinatum* x *Verticordia plumosa* hybrid.

Cylindrocladium also infects the leaves and stems, particularly in nurseries. These low level infections may be the source of later field infections.

Treatment of root and collar rot

Few chemicals are registered for control of *Cylindrocladium* but drenches appear to be the most effective.

Armillaria

Root rot associated with *Armillaria* spp. has been found in waxflower plants, but it is not known exactly how susceptible the plant is to this pathogen.

Symptoms are poor growth and slow decline. Plant roots have galls which vary in size (but are larger than nematode galls) and texture (spongy to hard) and poor root development.

Armillaria is a fungus which survives on the root material of native trees left after clearing. It invades the root systems of a very wide range of woody plants, gradually starving and eventually killing them.

Treatment for Armillaria

There is no control for plants infected by *Armillaria*.

Sites may be prepared by deep-ripping and removing all root debris then allowing adequate time for breakdown of plant residues before planting.

Nematodes

There are several pathogenic nematodes. *Meloidogyne* (root knot nematode) is the most common, but *Pratylenchus* (root lesion nematode), is also found in waxflowers in Western Australia.

Not all nematodes cause galls on roots, and above ground symptoms may be indistinct. Infested plants lack vigour and may be more prone than normal to other diseases. Root systems can be stunted or stubby; root branching may be abnormally prolific; and galls may be present (with root knot nematodes).

Treatment for nematodes

Most growers choose to chemically sterilise the soil prior to planting. If time permits, nematode numbers may be reduced prior to planting by heavy cropping with a high plant density of non-susceptible break crop host such as particular varieties of marigolds (not all cultivars are effective).

Once a nematode problem exists, regular checks on numbers should be made. It is very hard to eliminate nematodes successfully, particularly where drip systems of irrigation are used.

Fenamiphos (Nemacur®) is the only current practical treatment for established plants. It is important to note that repeated use of Nemacur® can considerably reduce its effectiveness due to a condition called enhanced biodegradation.

Plant nutrition and disease

Any plant that is properly fed will be better at resisting both disease and insect attack. The role of some nutrients in plant immunity to disease is outlined below:

Nitrogen—the effect of nitrogen on a plant's susceptibility to disease changes with the type of pathogen involved. High nitrogen levels generally make plants more susceptible to attack from diseases such as powdery mildew. Low nitrogen levels enhance infection by *Botrytis*, *Alternaria* and *Rhizoctonia*.

Nitrogen also has an overall effect on plant form. High nitrogen levels promote new growth, which may increase humidity within the plant canopy and enhance the spread of infection. High nitrogen levels may also decrease the concentration of silicon in plant tissue (dilution effect) and thus have an adverse effect on plant resistance to infection.

Silicon—(supplied as potassium silicate or metasilicate) has been reported to strengthen cell walls making pathogen infection more difficult. Silicon also accumulates around infection sites.

Trials have shown that liquid feed silicon at 100 ppm reduced infection by powdery mildew, *Botrytis* and *Pythium* in cucumbers. In other plants, applications of silicon in foliar sprays (1000 ppm) have proved more beneficial. These approaches are worth trialling on waxflowers.

Potassium—when plants are deficient in potassium, both soluble carbohydrates and soluble N compounds accumulate, and starch levels decrease. This has an effect on the quantity and composition of plant exudates which, in turn, enhances the germination of fungal spores on leaf and root surfaces. Potassium deficiency has several other effects on plant structure and function:

- increased cell membrane permeability
- cuticles are weaker and cell walls are thinner making it easier for fungi to penetrate cells
- lignification of cell walls and the deposition of silicon is impaired
- stomata remain open longer so the entry of fungal spores is enhanced.

Calcium—has several effects on plant structure and disease susceptibility. Low calcium increases cell wall permeability, reducing its stability. This allows the mycelium of fungal pathogens to penetrate. High calcium levels inhibit pectinase, an enzyme which many fungi and bacteria produce to dissolve cell wall components during the infection process.

Other nutrients—many other nutrient deficiencies including boron, manganese, zinc and copper have been shown to adversely affect a plant's ability to resist disease even before deficiency symptoms are visible.

Waxflowers are susceptible to a number of above- and below-ground diseases. Because it is not practical to keep foliage dry, control of diseases on flowers, leaves and stems can be more difficult than in some other crops. However, balanced plant nutrition combined with timely application of fungicides can help ensure the best quality product with good shelf life.

For assistance with disease identification and control, contact your local adviser. Several states run plant disease diagnostic facilities.

Note: Fungicides registered for use on waxflowers may vary between states due to minor use permits.

Further reading

Department of Agriculture and Food, Western Australia:

- Bulletin 4683 *Sampling and testing for plant pathogens.*
- Bulletin 4682 *Phytophthora diseases of cutflower crops.*
- Bulletin 4583 *Diseases of waxflower and their control*.

Reuveni R, Reuveni M, Agapov V (1994) *Effects of foliar sprays of phosphates on rose powdery mildew (Sphaerotheca pannosa)* Journal of Phytopathology, 142: 331–337.

Tjosvold SA and Koike ST (2001) *Evaluation of reduced risk and other biorational fungicides on the control of powdery mildew on greenhouse roses.* Acta Horticulturae No. 547, Proceedings of the Third International Symposium on Rose Research, pp. 59–67.

10. Weed control in waxflower crops

Weed control essentials

Biosecurity plan:

- prevent weed seeds entering your property on vehicles, machinery or plant material.

Site preparation BEFORE planting will minimise the weed seedbank.

Weed control is most critical at crop establishment (competition).

Integrated weed control is a practical approach—use a combination of:

- cultivation
- hand weeding
- herbicides
- mulches
- inter-row cover crops.

Why control weeds?

Weeds compete with crops for nutrients and moisture. Optimal growth rates are achieved with woodchip mulch or bare ground—weeds can reduce plant growth rates through competition.

Weeds may also serve as alternative hosts for pests such as thrips or diseases. Heavy weed growth creates a better environment for pests and diseases to multiply and makes effective spraying difficult.

Keeping soil bare is not always the best option. Depending on soil type, it may bring problems such as loss of soil structure, erosion and compaction. Beneficial organisms may also require a habitat additional to the crop itself.

In perennial crops such as waxflower, it is beneficial to rotate weed control methods—cultivation, hand weeding and herbicides.

Cultivation

Mechanical cultivation can effectively control weeds and is an important part of crop production, if conducted properly.

Before planting—soil preparation to eliminate weeds and develop a good bed before planting normally involves repeated cultivation. It is important to note that excessive cultivation breaks down soil structure which is important for drainage, aeration and root penetration. In heavy or wet soils, 'pans' or compacted layers, form at the bottom of plough and cultivator blades, and interfere with water infiltration and root penetration. These pans have even been found on vegetable properties on the coastal sands.

Once established—cultivation may damage or destroy crop roots, and weed problems may temporarily increase as buried weed seeds are brought to the soil surface. Dust from cultivation and bare soil may also contaminate the crop, reducing the marketability of flowers.

Mechanical cultivation complements other weed control methods but should be used as little as possible. Keep it shallow (5–10 cm), and ensure that clay or loamy soils are not wet to reduce soil compaction.

Hand weeding

Hand weeding, whilst having minimal impact on soil structure, is labour intensive and may not be effective for perennial weeds such as couch.

Herbicides

The correct use of herbicides will reduce or eliminate weeds without harming the environment. Herbicide use may reduce soil compaction by decreasing traffic movement compared to cultivation. Heavy spray rigs, however, can still compact soil. Many herbicides are applied only once or twice per year and require little labour, making this a cost effective option.

All herbicides are categorised in three ways, as:

- pre-emergent or post-emergent
- selective or non-selective
- residual or non-residual.

Pre-emergent herbicides

In general, pre-emergent herbicides need to be applied to weed-free soil. Some act to prevent seed germination or root growth, while others kill or inhibit new shoots. They are relatively ineffective against established perennial weeds.

Post-emergent herbicides

Post-emergent herbicides are applied to established weeds.

Selective herbicides kill only certain types of plants. Fluazifop (Fusilade®) and clethodim (Select®), for example, kill or suppress grasses without harming most broad-leaf plants. Herbicides that contain bromoxynil kill broad-leaf plants but don't harm grasses.

Some post-emergent herbicides are not selective and kill most or all plants—for example Spray.Seed® (a mixture of paraquat and diquat), glyphosate and Basta®. Some (such as Spray.Seed®) are not translocated within the plant, that is, they are contact herbicides only and are not as effective on perennial weeds (below-ground parts are not killed and the weed can regenerate). Glyphosate on the other hand is systemic and moves readily from the leaves and green stems into the roots and rhizomes, killing both roots and tops (often used to kill all vegetation prior to planting). Basta® is not easily translocated so its effects on the plant are between glyphosate and Spray.Seed®.

While herbicides are generally safe to use around the base of plants if the tissue is woody/lignified**, glyphosate needs to be used with caution** around plants because of its systemic nature. A hooded sprayer can help to prevent spray contacting the base of waxflower plants.

An organic herbicide based on pine oil is registered for use in Western Australia. Bioweed Herbicide Concentrate® acts as a contact, non-selective post-emergent herbicide.

Chemical resistance

Repeated or excessive use of one or a few herbicides can result in weed populations that are resistant to those herbicides.

Chemical toxicity

Some herbicides, such as paraquat, are dangerous to health. Paraquat is readily absorbed through the skin. It is essential to avoid splashes or any type of skin or breathing exposure.

Chemical registration

In order for you to legally use a herbicide, it must be registered for your particular crop. Few herbicides are registered for use on ornamentals and those that are, tend to be more expensive to use.

In 1989/90 DAFWA conducted scientific trials using various of pre- and post-emergent herbicides on a range of native species, including waxflowers. Those that showed promise for use on waxflowers are listed in Table 10.1. Minor use registration is an option the industry could profitably pursue for some of those listed. Table 10.2 gives examples of herbicides that are suitable for use in waxflower plantations.

Best management practice

The best management practices for herbicides minimise their use, while maintaining weed control.

- Reduce the risk of developing herbicide resistant weeds by alternating between chemical groups and never exceed label rates.
- Target your applications. Instead of using herbicides over the whole area, consider leaving alleys planted with a cover crop and use herbicides only in narrow bands along the crop rows.

Table 10.1. Herbicides for weed control on waxflower

Active ingredient	Trade name/s	Chemical group	Comments
bromoxynil	Bromicide®	C	Post-emergent activity
chlorthal-dimethyl	Dacthal®	D	Doesn't control clovers, wild radish/turnip
diflufenican	Brodal Options®	F	Mostly post-emergent activity
linuron	Linuron®, Afalon®		Some post-emergent activity
metribuzin	Sencor®, Lexone®, Buzz®; Dorado®, Tomahawk®	C	Some post-emergent activity
norflurazon	Solicam®	F	Supposed to last six months. Mix with simazine for control of portulaca
oryzalin	Surflan®	D	Apply to bare soil. Do not disturb after that.
oryzalin/ trifluralin	Duet 250 EC®, Yield®	D	
oxadiazon	Ronstar®	G	
oxyfluorfen	Goal®, Striker®, Spark®	G	Rate trialled on wax was only 1 L/ha, 4 L/ha normal recommendation
prometryn	Gesagard®	C	
simazine	Gesatop®	C	Little post-emergent activity

Note: It is important to rotate chemical groups to avoid herbicide resistance in weeds.

Table 10.2. Post-emergent herbicides for weed control in waxflower

Active ingredient	Trade name/s	Chemical group	Comments
fluazifop-P	Fusilade®	A	Only controls young grasses. Does not control winter grass (*Poa annua*) or silver grass (*Vulpia* spp.). Low cost for annuals, high cost for perennials
glyphosate	Roundup®, Glyphosate®	M	Non-selective. Take care not to spray on wax foliage or stem.
glyphosate-trimesium	Touchdown®	M	Safer than glyphosate if accidental drift occurs
paraquat + diquat	Spray.Seed®, Tryquat®		Safer than glyphosate if accidental drift occurs
pine oil	Bioweed Herbicide Concentrate®	-	Organic herbicide
sethoxydim	Sertin®	A	Best option for ryegrass. Fusilade better for brome and barley grasses

Note: It is important to rotate chemical groups to avoid herbicide resistance in weeds.

- Use the lowest label rate that gives adequate control—some herbicides may require fine-tuning to establish the best rate for your soil type. As the weed seedbank and weed pressure decrease, you may be able to reduce herbicide application rates.
- Hit critical timings for herbicide effectiveness. For example, selective herbicides such as Fusilade® and Sertin® work well on small weeds to the 2–4 leaf stage, but will not work on established weeds that are a metre high and seeding.
- Always follow label registration and application instructions.

Mulches—organic

Organic materials such as sawdust, straw, and bark work principally by excluding light (and to a degree, moisture and oxygen). This inhibits weed seed germination, and may weaken or kill established weeds. There is also evidence that the uneven nature of the mulch surface can trap fungal spores and help reduce the spread of some diseases. As mulches decay, they contribute organic matter and nutrients to the soil.

However, there are a number of downsides to the use of organic mulches:

- The cost of purchasing, transporting, and applying them.
- Mulches can interfere with crop nutrition, especially nitrogen, as they are decomposed by soil micro-organisms.
- Due to their organic nature, mulches can be non-wetting and so prevent rain or irrigation from reaching the soil below.
- If the soil dries out, rainfall must wet up the mulch before reaching the soil—this means that the crop may not benefit from small rainfall events. For this reason, drip irrigation should be installed below the mulch (however, this makes it harder to see if any drippers are not working).
- Crop roots may grow into the mulch if it is too fine making them more susceptible to drought, freezing injury, and damage from hand weeding.
- Fine mulches have a shorter useful life as weed seeds blow in and are able to germinate on the surface.
- Organic mulches aren't very effective in controlling perennial weeds such as thistles and couch.
- They may be a fire hazard.
- They can greatly increase rodent problems.

If you have a plentiful, inexpensive supply of organic mulch, by all means use it to control annual weeds but be aware you need to eliminate perennial weeds before you apply the mulch.

Monitor crop nutrition carefully and, if necessary, add fertilisers such as IBDU® to offset deficiencies caused by the mulch. Use coarse mulches, such as wood chips and green waste, in preference. If you use straw or green waste, make sure it's free from weed seeds or you may end up with more weeds, not less!

It is important to note that pruning off-cuts from waxflower crops should not be used as mulch unless they have been properly composted, as it may increase the spread of insect and disease problems.

Mulches—inorganic

Weed mats and plastic films are also used to control weeds. They work by preventing weeds from growing through the fabric and by preventing the roots of germinating seeds from reaching the soil.

White plastic is generally used in warmer climates such as the northern waxflower growing regions of Western Australia, while black plastic is used in the cooler southern areas. Clear plastic does not prevent weed growth.

Like organic mulches they have a number of downsides.

- They tend to be expensive when used over large areas.
- As the materials break down they create disposal problems for growers. Most plastic films last only one to two years. Biodegradable plastic films degrade when exposed to UV light—creating litter from blowing fragments. Buried films may not degrade at all.
- Some weeds such as nutsedge and couch penetrate even heavy weed mats. Roots from germinating weed seeds can penetrate many weed barrier fabrics, especially if the mat is covered with soil or leaf litter.
- Non-porous films prevent oxygen from moving into the soil, and can inhibit root development as well as interfering with irrigation and fertilisation.

Overall, porous weed mats tend to give better control and have fewer problems than black plastic, and should last longer. Unfortunately the range of weed mats available in Australia is limited and many do not last long or come without a guarantee.

One of the better ones appears to be Lumite (about 110 g/m^2) which is American and comes with a five-year guarantee. While there is no distributor in Australia, the company does supply orders of sufficient quantity.

Marix cloth has been around for some time but is only 30 g/m^2. There are other weed mats from Taiwan, Korea and China of varying thickness and quality.

Solarisation

Solarisation uses solar energy to heat the soil—controlling weeds and soil pathogens.

One or two layers of clear plastic are laid directly over moist soil. Heat trapped by the plastic kills pathogens and weed seeds directly. Some weed seeds germinate and are then killed by the high temperatures.

Though suited to our Mediterranean summers, it is generally not practical for large areas. In perennial crops, it can only be used in the initial planting phase. Because it is hard to achieve high temperatures at depth, it is not effective beyond a few centimetres.

Cover crops

Cover crops are grown for their benefits to the soil and cash crops, and generally aren't harvested. They control weeds by competing for light, moisture, space and nutrients. Some cover crops also release chemicals that prevent other plants from growing around them (allelopathy).

Cover crops may be permanent or replaced annually. In permanent cover crops, a dense sod of grasses, broad-leaf plants, or a combination, is established and left in place from year to year.

In addition to controlling weeds, cover crops:

- help support beneficial organisms
- maintain or improve soil structure, add organic carbon
- may reduce soil compaction/erosion
- reduce nutrient run-off and leaching by trapping nutrients and releasing them back into the soil slowly
- provide good working surfaces and reduce dust contamination of crops.

However, there are some drawbacks.

- They require money and labour to establish and may require irrigation, periodic mowing, fertilisation, and pest and disease control.
- Cover crops may compete with cash crops for nutrients and moisture. Even clover cover crops utilise soil nitrogen in their early growth stages.
- Rodents can become problems with certain legumes because the plants produce hard seeds and fleshy roots which the rodents feed upon.
- Some cover crops harbour pests and diseases that attack perennial crops.

Living mulches should be low growing, tough, durable, tolerate mowing, and require little care.

The choice of crop depends on climate and soil type. Annual cover crops are often used in drier areas where permanent cover crops might compete excessively for moisture or where growers choose not to irrigate alleyways.

Annual cover crops are generally mowed before their seeds ripen to prevent them from becoming weeds.

Combinations of small grains and legumes (barley and peas, for example) make effective, diverse covers that control weeds and support populations of beneficial organisms. Residue from cover crops planted in the autumn may be tilled under in spring or mowed short and left until the next cover is planted.

Flame and steam weeding

These are non-chemical methods of weed control.

Flame weeding uses propane for fuel and can only be used on relatively small weeds. The equipment used to deliver the flame can be set up with baffles to direct the flame away from the crop rows if necessary. Irrigation lines need to be buried or lifted above the ground to avoid melting. Flame weeding is a fire risk in summer.

Steam weeding sprays superheated water or steam from a boom attached to a diesel-fired boiler which is towed on a trailer behind a tractor. A relatively clean (low salinity) water supply is needed to avoid corrosion of equipment over time.

Using current technologies, both these methods of weed control tend to be too expensive for large scale use.

Integrated weed control

Effective long-term weed control usually involves a combination of methods.

Prior to planting, a combination of cultivation and non-selective post-emergent herbicides is often used. Cultivation can also be used to prepare a weed-free surface for pre-emergent herbicide application.

Many growers use pre- and post-emergent herbicides to maintain a strip of bare soil along the rows, and have annual or perennial cover crops in the alleyways. By using a side discharge mower to cut the annual or perennial cover crop, you can apply the cover crop residue as mulch within the rows.

Alternatively, mulches can be used within the rows, and cover crops and/or cultivation between the rows. Some hand weeding and/or spot spraying is generally required in mulch systems.

Conclusion

No single weed control option is best for every grower or for any grower all of the time. Weed control will be ongoing for the life of the planting. By controlling weeds effectively before planting and by using a variety of control methods, growers can enhance long-term weed control and improve production while protecting the environment.

11. Harvest—picking waxflower stems

Harvesting essentials

Ensure that you:

- have enough labour available to harvest and pack stems
- know your variety specifications (stage of picking, stem length etc)
- set up your packing shed to handle the predicted quantity of stems.

Set your harvest schedule.

Choose your harvesting process—bunch in the field, or cut and bunch in the shed.

Keep a record of the season's harvest for comparison.

Planning production and harvest sequence

It is important to estimate the stem or bunch yield expected from varieties on the plantation. You need this information to ensure that your processing resources for picking and postharvest can cope with the volume of stems.

It is a good idea to plot up a graph of last year's variety mix harvesting schedules. This information will also be useful in determining the amount of product that will be available for sale at different times throughout the season, allowing exporters to establish markets.

Stage of picking

Waxflowers for the cut flower industry, particularly Pearlflower varieties, are mostly picked when 50–90 per cent of flowers are open. However, it is important to check with the variety specifications and your buyer's requirements (Figure 11.1).

Picking at later stages when nearly 100 per cent of the flowers are open, can be risky in terms of flower quality as at this stage some flowers are ageing and are likely to have shorter vase life (Figure 11.2).

Pick only as long as flowers remain fresh. The stage at which this occurs depends on variety and the conditions during growth and up to harvest. It is therefore important to check to maximise quality and vase life to best meet market requirements.

Figure 11.1. Pearlflower at 90 per cent flower open stage

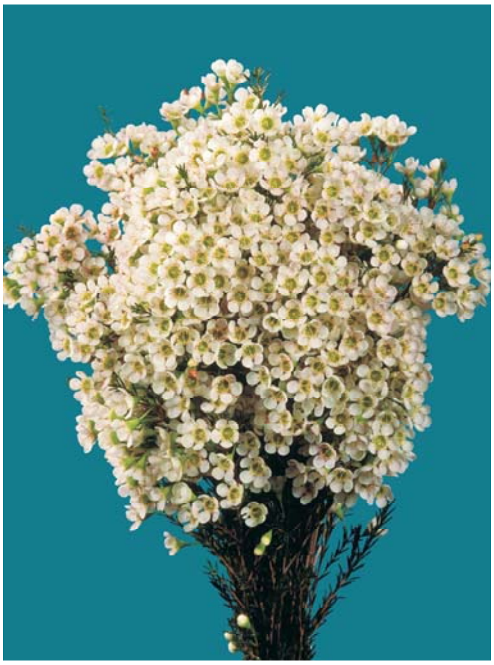


Figure 11.2. Bunch presentation for Bridal Pearl picked at almost 100 per cent open flower stage

When picking budwax, the cap should be fresh and spongy with full colour and not papery (Figure 11.3).

Figure 11.3. Laura Mae Pearl*Ⓓ *picked as bud wax when the cap is spongy and in full colour

Harvest specifications

Specifications are the standards which your waxflower bunch, leaves, stems and flowers must meet. They may include number of stems per bunch, flower and leaf colour, harvest stage, stem length, stem thickness, damage, grow-past, contamination, pests and diseases.

While there are general specifications for waxflowers, it is worth checking to see if your buyer has their own specifications for each specific variety.

A national quality specifications project has recently been completed, and guidelines will be available in 2010 for use by growers, wholesalers and exporters. The two relevant sections for waxflower growers from RIRDC project PRJ-000331 2006–2009 are:

- *Quality specifications for Australian wildflowers: Pearlflower.*
- *Quality specifications for Australian wildflowers:* W*axflower.*

Methods of harvesting

Stems can either be hand-picked and bunched in the field, or they can be cut by hand or mechanical pruners (such as hedge trimmers) and carted to the packing shed for grading and bunching.

Hand-operated **hedge trimmers** have been used effectively to remove all the stems from a bush. These are then loaded onto trailers for removal to the shed for bunching. This method is much faster than **secateurs** but is not as selective as hand cutting of stems with secateurs. This means that stems coming into the shed will be of varying quality and will need extra sorting to produce quality bunches. Waste from a typical waxflower plant can be as high as 30 per cent.

Hedge trimming has the additional advantage of also pruning the bush at the same time as picking of stems (refer to Chapter 5 on canopy management).

There are no mechanical harvesters/bunching machines specifically designed for waxflowers. Use of adapted hay cutting machines are generally not warranted, as running such machines will harvest more stems than can be handled by most packing sheds. This bottleneck of stems in the field will result in loss of quality.

Bunching

Stems can either be bunched in the field or transported to the packing shed and bunched. Bunching in the field reduces double handling, however, as it is more difficult to maintain quality control, further adjustments will be needed in the packing shed.

Hydration

It is critical that the waxflowers do not suffer any water stress during harvesting and that they are not left in heaps on the ground—in the field or packing shed—as bunches can start composting.

Overheating of flowers reduces vase life and quality, and increases the likelihood of flower drop.

To avoid this, particularly in the hotter part of the year, move bunches from the field to the shed quickly and process promptly.

If this is not possible, stand bunches or stems in water and keep them in the shade, then transport to the packing shed as appropriate. One way to do this is to have trailers with trays of water and canopies over the flowers to shade them.

The degree of hydration of waxflowers may impact on the effectiveness of anti-ethylene treatments such as STS procedure (see Chapter 12 on postharvest ethylene management).

Further reading

Rural Industries Research and Development Corporation:

- Publication series 10/040 *Quality specifications for Australian wildflowers: Pearlflower.*
- Publication series 10/040 *Quality specifications for Australian wildflowers:* W*axflower.*
- Publication 10/027 *Postharvest handling of Australian flowers from Australian native plants and related species* (2nd edition).

Postharvest processes for premium waxflowers

There are alternatives for the order in which postharvest treatments are conducted on waxflower.

While the treatments are described in the next few chapters, you can select the most appropriate order for your system.

Either

1. Anti-ethylene treatment
2. Devitalisation
3. Disinfestation.

1. Anti-ethylene treatment *(Chapter 12)*

STS quick pulse

- Buy or make 40 mM STS stock solution
- Dilute stock solution to **4 mM**
- Stand stems in **50–75 mm** solution
- **10–15 min** at **20 °C** and **50% humidity**
- Remove, stand stems in clean water

Check uptake and solution regularly

Note: Pulsing time must be adjusted according to the time required for uptake of 10–15 mL per 450 g bunch. Pulsing time will take longer in cooler temperatures and less time in warmer conditions.

2. Devitalisation *(Chapter 13)*

Dipping

- Take anti-ethylene treated flowers
- Prepare **0.25%** solution of **Roundup**® (360 g/L glyphosate)
- Submerge whole bunch for **1 min** and agitate to ensure full coverage
- Remove bunch, shake off excess moisture, stand stems in clean water while foliage dries

Can be combined with disinfestation

OR

Pulsing

- Take anti-ethylene treated flowers and recut stems under water
- Prepare **0.1%** solution of **Roundup**® (360 g/L glyphosate)
- Stand stems in **75–100 mm** solution for **20 min** at **20 °C**
- Remove from solution and stand stems in clean water

Check uptake and solution regularly

3. Disinfestation *(Chapter 14)*

Fill dipping tank—for every 100 L water add the following rates of each ingredient:

10 mL Agral 600® and

250 mL Cislin® (10 g/L deltamethrin) and

100 mL Rovral AquaFlo® (500 g/L iprodione)

Note: Tank must be stirred while adding chemical, as well as during and between dipping.

- Submerge whole bunch for **1 min** and agitate to ensure full coverage
- Remove bunches and drain excess from bunches back into tank
- Stand stems in clean water while foliage dries
- Pack flowers and **cool to 2 °C**

Can be combined with devitalisation

Postharvest processes for premium waxflowers

Or:

1. Devitalisation
2. Disinfestation
3. Anti-ethylene treatment.

1. Devitalisation *(Chapter 13)*

Dipping

- Prepare **0.25%** solution **Roundup®** (360 g/L glyphosate)
- Submerge whole bunch for **1 min** and agitate to ensure full coverage
- Remove bunch, shake off excess moisture, stand stems in clean water while foliage dries

Can be combined with disinfestation

OR

Pulsing

- Recut stems under water
- Prepare **0.1%** solution of **Roundup®** (360 g/L glyphosate)
- Stand stems in **75–100 mm** solution for **20 min** at **20 °C**
- Remove from solution and stand stems in clean water

Check uptake and solution regularly

↓

2. Disinfestation *(Chapter 14)*

Fill dipping tank—for every 100 L water add the following rates of all three ingredients:

10 mL Agral 600® and

250 mL Cislin® (10 g/L deltamethrin) and

100 mL Rovral AquaFlo® (500 g/L iprodione)

Note: Tank must be stirred while adding chemical, as well as during and between dipping.

- Submerge whole bunch for **1 min** and agitate to ensure full coverage
- Remove bunches and drain excess from bunches back into tank
- Stand stems in clean water while foliage dries

Can be combined with devitalisation

↓

3. Anti-ethylene treatment *(Chapter 12)*

STS overnight pulse

- Buy or make 40 mM STS stock solution
- Dilute stock solution to **0.2 mM**
- Stand stems in **50–75 mm** solution
- Place in coolroom for **16 hours** at **2 °C**

Check uptake and solution regularly

OR

1-MCP *(Ethyl Bloc® sachets)*

- Buy sachets
- Half fill the packing carton with flowers
- Place **1–2 sachets** per **0.1 m³** between top and bottom layers of flowers
- Pack the rest of the flowers on top of the sachets
- **Cool flowers to 2 °C**

12. Postharvest ethylene management

Postharvest ethylene management essentials

Waxflowers are very sensitive to ethylene.

Ethylene causes flower drop.

Ethylene is produced by:
- flowers and plants under stress
- fruit and vegetables
- machinery exhaust fumes.

Flowers need protection from ethylene:
- initially before harvest in the field—regular spraying for *Botrytis* once flowers start to open
- continuing in the shed—dipping in fungicides.

To protect flowers from ethylene after harvest use one of the following:
- quick pulse in STS
- overnight pulse in STS
- 1-MCP sachets.

Most waxflowers are sensitive to ethylene. It takes only very small levels of ethylene (1 ppm) to cause up to 85 per cent of flowers to drop from stems (see Figure 12.3). These levels are often reached in cool rooms or refrigerated transport containing other produce such as apples.

Varieties are tested to determine their sensitivity to ethylene (Figure 12.1). Older varieties such as Purple Pride, Alba and Mullering Brook are particularly sensitive to ethylene.

Figure 12.1. New waxflower varieties are tested for ethylene sensitivity and vase life

The Pearlflowers are less sensitive to ethylene, along with the inter-generic hybrids such as Eric John and Jasper⊕.

Why do waxflowers drop when exposed to ethylene?

Waxflowers have a special layer of cells joining the flower to the stalk or peduncle (abscission layer). On exposure to ethylene, this layer loosens, causing flowers to fall off (Figure 12.2).

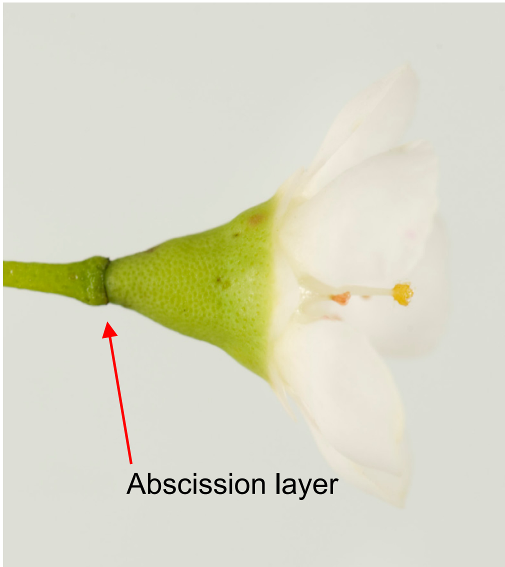


Figure 12.2. Abscission layer in waxflower

Where does ethylene come from?

Exposure of waxflowers to ethylene can originate from external sources such as engine exhaust fumes as well as by storing flowers with other produce such as apples and pears, which produce ethylene.

Ethylene can also be produced by the flowers themselves in response to stress or disease such as *Botrytis*. *Botrytis* may be present on flowers from the field and if the flowers heat up, for example in transit, the fungus proliferates and produces enough ethylene to affect their vase life.

Anti-ethylene treatments

As an insurance against possible exposure to ethylene, waxflower stems require an anti-ethylene treatment during postharvest processing. This involves an STS (sodium thiosulphate) pulse or the new technique of using 1-MCP as an alternative. There are advantages and disadvantages of each chemical (see Table 12.1).

STS treatment

Pulsing involves standing stems in a solution of STS. STS may be purchased commercially or mixed on site. Commercial supplies of STS may be purchased from Daly Laboratories Pty Ltd in Perth (telephone (08) 9358 5445) or other suppliers.

There are two methods for STS pulsing—a quick pulse or an overnight pulse. Each is performed at a different concentration.

Quick pulse

The quick pulse method involves uptake of a higher concentration of STS for a period of 10–15 minutes and precedes devitalisation and disinfestation:

- take 2 L of 40 mM stock solution and make up to 20 L with good quality water and stir thoroughly *(this produces a 4* mM *solution of STS)*
- stand stems in 50–75 mm of STS solution
- leave for 10–15 minutes at 20 °C and 50 per cent humidity
- remove flowers from STS and stand stems in fresh clean water
- proceed to devitalisation and disinfestation processes before placing flowers in a cool room (2 °C).

Pulsing times and conditions

Generally aim for 10–15 mL/450 g bunch which should take approximately 20 minutes at 20 °C and 50 per cent relative humidity.

Uptake should be checked using a 500 mL measuring cylinder. Stand a bunch in STS solution in the cylinder and note the volume before and after pulsing as well as temperature and relative humidity during pulsing. **This rate then becomes your benchmark.**

Checks should be made during the days processing as conditions change.

The time of pulsing depends on:

- variety—some new varieties, especially hybrids, may require longer or shorter exposure to the STS solution (research is still underway)
- conditions in the shed— uptake will be faster under hotter conditions with circulating, dry air. In cooler, damper or more humid conditions with still air, uptake will be slower
- wet or dryness of bunch—if bunches are wet, then transpiration will be low and uptake will be slower. Place stems in clean water and cool to 2 °C as soon as possible after pulsing.

Ensure flowers are not pulsed for too long, as the silver solution is toxic at higher tissue concentrations. Rapid closing and withering of flowers may result if too much silver is taken up. Test to determine safe pulsing times.

Overnight pulse

With the overnight pulse, flowers are placed in a cool room overnight in a diluted STS solution. This practice is less common and follows devitalisation and disinfestation:

- take 100 mL of stock solution and make up to 20 L with good quality water and stir thoroughly *(this produces a 0.2* mM *solution of STS)*
- stand stems in 50–75 mm of STS solution
- while flowers are in their STS solution, move them into a cool room (2 °C) for 16 hours
- remove flowers from STS and stand stems in fresh clean water.

Caution: STS solution is poisonous. Avoid contact with skin. Wear protective clothing, waterproof apron, gloves and eye protection when handling solutions.

Testing STS solutions

Test kits are available, or can be prepared, consisting of 2 molar potassium iodide (KI) and 2 molar sodium chloride.

Use three 50 mL clean, dry containers:

1. contains 1 mL distilled water
2. contains 1 mL potassium iodide
3. contains 1 mL sodium chloride.

Sample STS solution and add 20 mL to each of the three duplicate containers, wait 10 seconds and observe effect. This will tell you whether your STS solution is working (test based on RIRDC Publication 10/027 *Postharvest handling of Australian flowers from Australian native flowers and related species*).

(1) **STS is working**—solution 2 will give a white or yellow precipitate (appears turbid) and solution 3 is clear. **Continue to use**.

(2) Solution 1 (the control) is discoloured or has a precipitate. **Replace STS solution**.

(3) No precipitate (solution is clear) in 2 or 3—there is not enough silver in solution. **Replace STS solution**.

(4) Precipitate (solution is cloudy) in 2 and 3—silver is present but is the wrong form for uptake by plant. **Replace STS solution**.

Varieties of waxflower vary in their response to STS and standard treatments do not apply to all.

Pulsing times need to be worked out for each new variety, for example, Mullering Brook and Jurien Brook appear to be very sensitive to STS and require shorter times than Purple Pride. Pearlflowers are more tolerant and respond well to a longer pulsing time.

1-MCP

MCP blocks ethylene-binding sites. There are two main methods of application—in sachet form or as a gas.

1-MCP sachets

An easy way to apply anti-ethylene treatment of 1-MCP is through the use of EthylBloc® sachets.

Table 12.1. Comparison of STS and 1-MCP as anti-ethylene treatments of waxflower

Anti-ethylene treatment	STS	1-MCP
Protection of flowers	Long lasting	Short (as low as 4 days)
Activity of chemical	Deteriorates over time, solution needs to be renewed	NA
Dose rate	Depends on variety, temperature, humidity and bunch size	Variety (unknown), temperature dependent
Overdosing	Can cause flower drop, shortened vase life	Repeated dose possible
Toxicity to environment	High	Low or none
Disposal of spent chemical	Difficult, silver	Not an issue
Clean and green image		Green

In this method, one to two sachets are added to a carton of approximately 0.1 m^3** of flowers during packing, preferably with sachets placed in the middle layer of flowers in the carton. The dampness of the flowers should activate the powder in the sachets, releasing 1-MCP gas into the carton, thereby treating the flowers.

Some limited preliminary laboratory tests have shown that flowers exposed to 1-MCP sachets are protected from ethylene gas (present at a level sufficient to cause flower drop in unprotected flowers) for up to four days.

As each situation on the farm and in the packing shed differs, such as the way flowers are packed and the size of the packing carton**, it is important that waxflower producers carry out real time tests on their farms and premises to ensure that flowers are adequately protected. It is also important to test flower performance during actual export to be sure that the sachets are providing protection of flowers during these real time conditions.

*** the exact number of sachets placed in a carton will depend on the size of the carton and the volume of flowers present and will need to be worked out for individual situations.*

1-MCP gas

1. Requires a reasonably airtight room or tent to apply 1-MCP.
2. 1-MCP comes in the form of a powder. It is activated by pouring a buffer solution into the bucket containing the powder through a hole in the lid. It reacts to produce a gas.
3. It is used at very low concentrations. Rate of 1 ppm (1 µL/L) or less.
4. Like STS it can be at various combinations of concentration, temperature and time.
5. One product used for producing MCP is EthylBloc® which is used for 4–8 hours at 10 to 25 °C and 6–18 hours at 1 to 3 °C.

Overcoming short-term effectiveness of MCP

MCP effectiveness appears to wear off with time as cells renew themselves. The time can vary from 2–25 days depending on conditions and the flower. For waxflowers this can be as short as four days. It may be necessary to repeat the treatment—this is still being investigated.

Testing effectiveness of ethylene protection

In a processing line, it important to test flowers for the effectiveness of anti-ethylene treatments by exposing flowers to ethylene and assessing flower and bud fall (Figure 12.3).

This is part of an anti-ethylene verification system devised by Doug Hall that is used at a number of export packing facilities.

It involves:

(a) testing STS solutions (mentioned above)

(b) checking amount of STS taken up

(c) subjecting flower stems to artificial ethylene exposure to see if ethylene protection (STS or 1-MCP) was effective.

Thanks to Daryl Joyce for his earlier contribution to this work.

Further reading

Department of Agriculture and Food, Western Australia:

- Farmnote 46/2004 *Cooling cut flowers and foliage*.

Further detailed discussion on methods of disposal of STS is given in a number of RIRDC publications.

Rural Industries Research and Development Corporation:

- Publication series 10/040 *Quality specifications for Australian wildflowers: Pearlflower.*
- Publication series 10/040 *Quality specifications for Australian wildflowers:* W*axflower.*
- Publication 10/027 *Postharvest handling of Australian flowers from Australian native plants and related species* (2nd edition).

Figure 12.3. Waxflower variety Mullering Brook before (left) and after (middle) exposure to ethylene and abscised flowers and buds (right)

13. Devitalisation of waxflowers

Devitalisation essentials

Devitalisation:
- is essential for the future of the Australian wildflower industry
- needs to be done by the industry as a whole to successfully protect varieties
- is simple and easy to do
- can be combined with postharvest disinfestation treatments
- does not affect quality of flowers.

Devitalisation will:
- give the industry maximum benefit from new varieties
- maintain marketing edge
- support the breeding of new varieties.

Devitalisation techniques have been developed to enable new varieties to be protected from being propagated by nurseries that are unlicensed to propagate the variety. The technique is only useful for varieties that have not been already released into the market place, however, it could apply to established varieties that are being released into new markets.

Devitalisation means that anyone who receives stems of flowers of new varieties will not be successful in striking roots on cuttings and making more plants. This restricts access to the new varieties and allows licensed growers in Australia to gain a full return from sales.

Use of the devitalisation process is a requirement for anyone who is contracted to grow and sell the new DAFWA-bred waxflower varieties.

What is devitalisation?

Essentially, devitalisation involves treating flowers postharvest before being sold as cut flowers. This treatment protects flowers so that they cannot strike roots from shoots or flower vegetative material.

Devitalisation is applied at the farm or packing shed after flowers have been graded and bunched and affords protection of flowers being propagated during sales and export.

Flowers can be devitalised as part of postharvest handling. In many situations this can be integrated and done with little disruption to the normal handling processes.

Methods of devitalisation

Two methods are available:

1. Dipping flower stems (Immersion)

This process may be combined with postharvest disinfestation.

- Completely immerse whole flower stems (bunches) in dipping tank containing 0.25 per cent solution of 360 g/L glyphosate (marketed as Roundup®) for 1 minute.
- Move flower bunches up and down, or mechanically agitate the solution in the dipping tank, to ensure complete contact and coverage of all surfaces of flower stems and flowers.
- Remove stems or bunches from the dipping solution and drain excess dipping solution back into the dipping tank. Excess dipping solution can be removed by gently flicking bunches—hold the end of bunches and move sharply downwards in an arc.
- Stand flower bunches in clean water, while allowing dipping solution to dry on foliage before packing or further treatment.

Dipping tanks can be small—use a 40 L bucket deep enough for flower stems to be plunged vertically into the dipping solution, or construct a tank using a 30 cm diameter storm water pipe (enclosed at one end).

For larger volumes, a larger square tank that can fit a crate of several bunches of flowers, and a gantry system for lifting the crate of flowers in and out of the solution, may be necessary.

Old baths are not considered suitable as flowers are often crushed when dipping several layers of flower bunches at a time.

2. Pulsing flower stems

This method requires less Roundup® solution.

- Stand stems in buckets containing a 75–100 mm deep 0.1 per cent solution of 360 g/L glyphosate (marketed as Roundup®) and allowed to absorb the glyphosate for 20 minutes at 20 °C.
- Remove from pulse solution, wash stem ends under running water and stand in fresh water to await further processing.

Note: Stems should be re-cut under water, before placing in pulse solution, if they have been out of water and dry.

If temperature is lower or higher than 20 °C, then pulse times need to be increased or decreased accordingly.

The effectiveness of the devitalisation solution depends on the condition of both the packing shed and the flower stems.

Growers will need to adjust pulse times according to temperature. Run tests at shed temperature to determine the length of time stems need to be pulsed to take up the same amount of glyphosate solution as they would at 20 °C.

Further testing is recommended to assess the effectiveness of each devitalisation batch. Check that root growth is inhibited in cuttings and flowers while vase life is maintained.

Figure 13.1. Punnets of cuttings taken from waxflower stems six weeks after Roundup® (right) devitalisation treatment compared to non-Roundup® (left) treatment

Devitalisation and vase life

DAFWA research has shown that **no decrease in vase life** of waxflower was seen after either:

- **dipping** completely immersed in a 0.25 per cent solution of 360 g/L glyphosate (marketed as Roundup®) for 1 minute
- **pulsing** in 75-100mm deep 0.1 per cent solution of 360 g/L glyphosate and allowed to absorb the glyphosate for 20 minutes at 20 °C.

No decrease in vase life, and some cases an enhancement of vase life* was seen in varieties such as Purple Pride, Albany Pearlⓟ, Bridal Pearlⓟ, WX 56ⓟ, WX 74ⓟ and WX 87ⓟ.

** Using higher rates of Roundup® than those recommended for dipping and pulsing methods can reduce vase life.*

14. Postharvest disinfestation of waxflowers

Disinfestation essentials

Dipping is the most effective postharvest disinfestation treatment for waxflowers.

Effectiveness relies on:
- good field control
- thorough wetting of foliage/flowers
- immersion for 1 minute
- maintaining a clean dipping solution (free of dead insects)
- renewing insecticide and fungicide regularly.

Disinfestation can be combined with devitalisation treatments.

Dip with insecticide, fungicide and wetter.

The presence of insects and/or disease in consignments of cut flowers can be a major problem in the export trade. It is particularly relevant for flowers being sent to Japan and the United States, where strict quarantine regulations apply.

Failure to rid flowers of pests and diseases results in rejection, fumigation or destruction of shipments at considerable cost and loss of business to the exporter. As a result, postharvest disinfestation treatments are standard practice in flowers for export.

Two common methods of postharvest disinfestation for cut flowers are fumigation and dipping.

- Fumigation is more expensive to set up and run, and has been found to be less effective than dipping.
- Dipping whole flower stems in insecticide and fungicide solutions is suitable for a range of cut flowers, especially waxflower and *Verticordia*.

Dipping involves completely immersing the flower and stems in insecticide and fungicide solutions. It is effective, as it gives complete coverage of all exposed flower parts, allowing contact between the pest or disease and the chemical.

Field control

Successful disinfestation relies heavily on the reduction of pest and disease levels in the field. Using an integrated pest management approach (IPM), insect numbers and disease levels are monitored, and outbreaks are sprayed in the field during the season only where necessary. It is particularly important to monitor for pests and diseases in the last two weeks prior to harvesting flowers.

An effective spray program that reduces insect numbers in the field to a manageable level will greatly improve postharvest disinfestation treatments.

Similarly, disease control programs in the field reduce spore loads on cut flowers making it easier to control these diseases with postharvest treatments. Including a fungicide during dipping ensures that diseases such as *Botrytis* do not emerge during transit. Fungal spores can proliferate during transport due to moist, warm conditions in cartons. This causes discolouring of flowers and also releases ethylene which results in subsequent flower drop.

Effectiveness of dipping

The effectiveness of an insecticide dip depends on the type of flowers being treated, the insect pest being targeted (and where it is located within flowers), the stage of insect development (for example, larvae or adult), the insecticide used, and the completeness of wetting of flowers during dipping.

Flower suitability

Assess the suitability for dipping of each flower species. Successful dipping relies on complete wetting of flowers—the insecticide must penetrate into crevices where insects may be hidden.

Flowers that have an open petal display are generally suited to dipping—for example, waxflower, a number of *Verticordia* species and tea-tree.

Phytotoxicity and damage

Before attempting a large scale dipping program, do a test run to see how effective dipping is for treating insects, and whether there is a phytotoxic reaction such as 'burning' or desiccation of flowers from the chemical used in the dip, or any other damage to flowers.

Small scale dipping

Small scale dipping is best done using a tank to hold the insecticide solution that is deep enough to allow stems to be completely immersed. There are a number of designs in use.

The bucket method uses a deep bucket or cylindrical tank—deep enough for single bunches to be held by their stems and immersed flower head first into the tank. Bunches are held under and agitated for one minute, allowed to drain and then removed.

Although this method is slow, it can be effective, causes little damage to flowers, and ensures correct timing of immersion.

The bathtub method uses an old household bath—set up at bench height and filled with insecticide solution. Bunches of flowers are loaded into the bath and weighted down for one minute.

This method is not recommended, as it is messy and wastes insecticide. It can result in operator contact with insecticide, stems can be crushed, and the timing of immersion is variable as bunches tend to get mixed up in the bath during dipping.

Larger scale dipping

The wire basket method uses baskets large enough to hold 20 to 30 bunches of flowers lying on their sides, suspended in a fibreglass tank of insecticide solution.

The insecticide solution is recirculated in the tank by a pump, which ensures the insecticide solution is moved through the flower bunches.

This system can be built so that there are several baskets in a production line layout. Baskets are removed after they have been in the tank for one minute.

The disadvantage of all these previous systems is that flowers must be handled several times during dipping and subsequent drying. This is costly in terms of labour and also can damage flowers.

The crate method is designed to allow flowers to be treated while they are held together in a crate. In this method, flower bunches are stood vertically in a standard fruit or vegetable crate.

The crate of flowers is then lowered into a dipping tank where they are completely immersed. After one minute, the crate is removed from the tank and stood on a draining board where excess solution drains back into the tank. The crate is then placed in a shallow tray with the stem ends remaining in water while the dipping solution dries on the tops of the flowers.

The crate system can be semi-automated for large scale production where dipping is timed, with crates of flowers being lowered and raised from the dip tank automatically (see Figure 14.1).

Figure 14.1. Dipping tank and draining board for treating a crate of 25 bunches of 60 cm long flower stems

The tank (695 mm wide by 510 mm deep by 750 mm high) is made of fibreglass or galvanised iron—see Figure 14.1 (in this case the iron needs to be coated inside with plastic paint). It has a draining board (660 mm wide by 690 mm long) with raised sides (40 mm). Stems are placed vertically in a crate that is 360 mm wide by 540 mm long by 320 mm deep.

The tank holds about 750 L of insecticide solution and allows, for example, one crate containing 25–30 bunches of 60 cm long waxflowers to be dipped.

Preparation of dipping solutions

The dipping solution should include both an insecticide and a fungicide to eliminate residual insects, and protect flowers from blights. It is also essential to include a wetting agent in the dipping solution to increase chemical contact between plant, pest and disease surfaces.

Deltamethrin (Cislin®) is registered for insect control in Western Australia, and can be used as a dip for cut flowers. Our trials show this insecticide to be effective against spiders, beetles, bugs, moth larvae and thrips on waxflowers.

Iprodione (Rovral AquaFlo®) is registered for disease control and is effective in a dipping solution for cut flowers.

To prepare your dipping solution

For each 100 L of water add:

- the water to the dipping tank
- then 10 mL Agral 600®
- then 250 mL Cislin® (10 g/L deltamethrin) and stir.

Then add:

- 100 mL Rovral AquaFlo® (500 g/L iprodione) and stir again.

Note: disinfestation may be combined with a devitalisation dipping process.

Submerge the whole bunch for one minute and agitate to ensure full coverage.

Remove the bunch and drain the excess dipping liquid back into the tank. Stand the stems in clean water while the foliage dries.

It is important to stir the solution in the tank repeatedly between dipping crates of flowers to ensure that the fungicide is kept suspended.

The crate system shown in Figure 14.1 allows the dipping solution to return to the dip tank from the draining board. Tests have shown that very little deltamethrin insecticide activity is lost with repeated use of the same dipping solution, if the flowers are relatively free from dirt.

The flowers will retain some insecticide solution during dipping, depleting the tank volume. The dip tank may be topped up with freshly prepared dip solution but **after five days of use, renew the entire dipping solution.**

Safety

Observe strict safety precautions during the preparation and use of dip solutions. The operator must wear protective apparatus and clothing at all times to be protected from splashes. If splashing occurs, immediately wash the chemical off the body with fresh, clean water.

The value of dipping

Dipping is a straightforward and effective postharvest disinfestation procedure. It is worth investing in good equipment such as a dip tank to make the procedure easier, faster and more effective.

Remember that it only takes the discovery of one insect for rejection of flowers in Japan, with the result of costly fumigation (up to $1000/consignment) and damage to flowers.

While the dipping method has not been tested on light brown apple moth (LBAM), the use of a wetting agent and a synthetic pyrethroid insecticide has been found to be effective on a number of insect pests of wildflowers.

Further information

For further information, contact
Kevin Seaton, Department of Agriculture and Food, Western Australia, South Perth (08) 9368 3244.

Department of Agriculture and Food, Western Australia:

- Farmnote 395 (2009) *Pests of export wildflowers.*
- Farmnote 394 (2009) *Postharvest insect disinfestation treatments for cut flowers and foliage.*
- Farmnote 108/94 *Disinfestation of wildflowers using insecticide dips*.

15. Cool chain management

Cool chain essentials

Cooled flowers maintain quality and extend vase life.

Store waxflowers at 1 to 2 ºC.

Maintain the cool chain from harvest to end user by:
- harvesting in cool parts of the day
- placing harvested flowers in water, in the shade while in the field
- moving harvested flowers to the processing shed as soon as possible
- processing flowers and getting them into the coolroom promptly.

It is crucial to maintain fresh waxflowers at low temperatures throughout the supply chain. This chapter discusses the practical considerations of cooling and storing waxflowers.

Management of the cool chain to maintain quality starts in the field, continues through processing and packing, and must be followed up by refrigerated transport from farm to market. Export logistics need to ensure low temperatures are maintained right through to the consumer.

Cool chain starts in the field

Wherever possible, flowers and foliage should be harvested in a cool part of the day, such as in the early morning. Late afternoon harvesting may be more desirable for proteas to help minimise leaf blackening. In hot areas, night picking could be a viable proposition where large areas are to be harvested.

Flowers cut in the day should be shaded from the sun, and any delay between picking and cooling should be minimised. 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 15 °C.

Cooling waxflowers

Plant material should be cooled as soon as possible after harvest to minimise deterioration. Cooling does this by reducing:

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

For example, cooling waxflowers from 20 to 10 °C reduces the respiration rate by about 71 per cent. Further cooling—from 10 to 0 °C—reduces the respiration rate by an additional 77 per cent.

Ideally, once flowers are cooled they should be kept cool because cycles of warming and cooling may produce condensation on the flowers leading to *Botrytis* and other storage diseases.

Simple thermocouple thermometers can be used for monitoring flower temperatures inside cartons during cooling.

There are a number of methods of cooling cut flowers the most common being:

1. room cooling
2. forced air or pressure cooling
3. other methods include vacuum cooling and rapid cooling.

Room cooling

The simplest method of cooling cut flowers is to stand them in buckets of preservative solution in a cold room. If circulation of cold air around the blooms is adequate, they cool quickly.

The main disadvantage with this method is that it is not an efficient use of space.

If packaged flowers are being stored in the same area, the fluctuations in temperature are not ideal, but this is generally not a problem unless the storage is long-term (that is, weeks rather than days).

If the flowers are packed in sleeves or cartons while still warm, room cooling is not very effective because of poor air circulation. More sophisticated cooling techniques are needed. Room-cooled flowers that warm up during packaging may also benefit from subsequent cooling within the carton.

Forced air cooling

Forced air, or pressure cooling, is the cheapest and most flexible way of cooling packaged flowers fast.

The technique involves drawing a stream of cold air through cartons of flowers to remove heat from flowers and cartons, quickly and effectively cooling flowers.

The movement of air through the boxes must be unrestricted. To minimise the risk of blockages, there should be holes, or preferably slots, on at least six per cent of the area of each carton face—through which air enters or leaves the cartons.

The pathway for airflow within the box must not be blocked by carton liners, packaging materials or by flowers being packed too tightly.

Methods of pressure cooling

There are a number of different ways cartons of flowers can be pressure cooled. While cold walls are a very convenient system to use, more simple, temporary systems, such as a tarpaulin pressure cooler may be appropriate.

Tarpaulin method

To set up a tarpaulin pressure cooler, flower cartons are arranged side by side lengthwise (one carton deep), placed on the cold room floor in two rows with a space of about 60 cm between the rows (Figure 15.1).

A fan is positioned at one end of the space between cartons and a plastic tarpaulin placed over the top of the space, resting on the cartons. Reinforcing battens are sewn into the tarpaulin at about half metre intervals to prevent the cover from caving in when the fan is running.

This is a simple pressure cooling system which sucks air out of the central space (plenum), drawing cool air through the cartons via the vent holes at each end of the carton.

The tarpaulin system described is only one of a range of designs to cause cold air to flow through flower cartons. Cold walls, where cartons are placed against slots in a rigidly walled plenum in the cold room, are also used for flowers. Air-jet conveyor cooling could also be considered. In this system, nozzles direct cold room air onto flowers in unlidded boxes as they pass by on a conveyor.

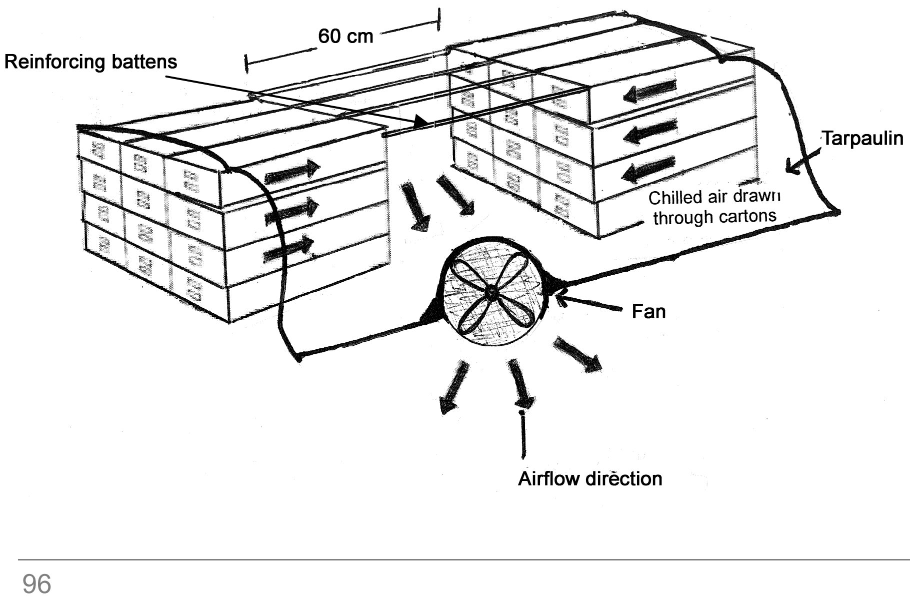


Figure 15.1. A simple tarpaulin pressure cooling system

Cold wall method

Cold walls are the best cooling method for everyday use by larger growers and exporters—requiring a dedicated coolroom. Figure 15.2 shows the components of the system.

The coolroom itself is designed with twin walls or plenums and baffles on both sides, and a gap at the top to allow air circulation. Boxes of flowers are brought into the coolroom on a conveyor belt and stacked against the wall. Along the top of each cold wall is a row of tarpaulins on rollers. These are attached to the wall just above the air gap. When pulled out over the top of each stack of cartons they help direct the airflow back into the plenum.

The refrigeration compressor that drives the system may be situated some distance from the coolroom, provided the pipe work is well lagged. In the coolroom, cold air is blown out into the room with a large fan. This causes a vacuum in the ducts above, which helps pull the air through the boxes and up into the wall, where it is then returned to the compressor to start the cycle again.

Temperature probes are placed in the boxes to monitor the cooling process and record the temperature of the air space in the boxes. Once the air inside is cool, a little extra time is required to ensure that the produce itself is also cooled to the same temperature. The cartons are then transferred to another coolroom where they are stored before shipping.

Other cooling methods

The most sophisticated way of cooling cut flowers and foliage is **vacuum cooling**. This method is suited to crops, with a high ratio of surface area to volume. Nevertheless, there is some risk of excessive water loss with vacuum cooling.

At reduced pressures, water boils at lower temperatures than it does at normal atmospheric pressure. For instance, at 0.6 kPa (0.6 per cent of atmospheric pressure), water will boil at 0 °C. As water vaporises from the plant material it draws heat energy away, thereby cooling it.

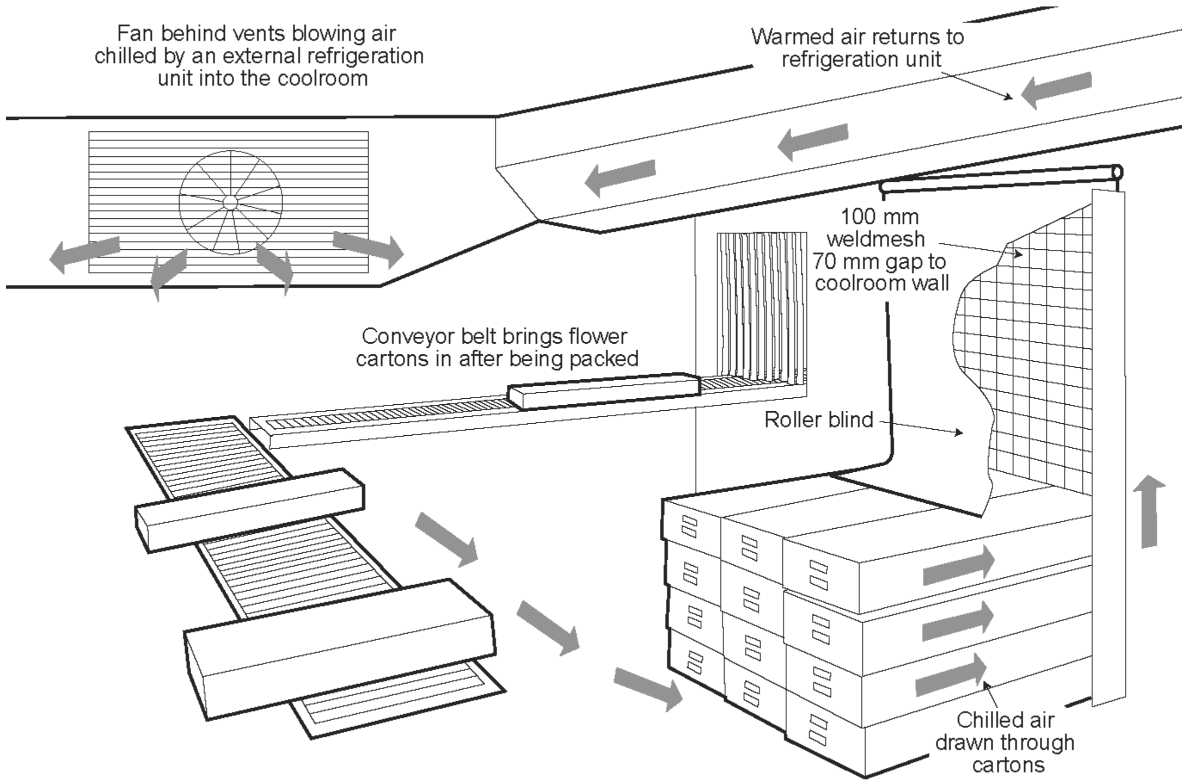


Figure 15.2. Schematic diagram of cold wall cooling of flower cartons

To cool 1 kg of plant material by 1 °C requires the evaporation of about 1.85 g of water. To cool 1 kg of plant material by 20 °C (say from 25 down to 5 °C) would therefore require evaporation of 20 x 1.85 g that is 37 g of water. This represents a loss of 3.7 per cent of plant weight. Such a big loss of water may be unacceptable for some flowers, as it could bring them close to wilting.

Another disadvantage of vacuum cooling is the high cost of the equipment. Fortunately, there is a cheaper and more flexible alternative—forced air cooling.

Rapid cooling methods involving free moisture, such as hydro-cooling, top-icing and liquid-icing, are not appropriate for cut flowers and foliage.

Calculating airflow requirement

Matching fan capacity and airflows

Airflow through the cartons needs to adequately cool the flowers in the cartons and can be calculated as follows:

As air moves through a carton of flowers there is a drop in pressure. The pressure drop specification, between the outside of the pressure cooling system and inside the central plenum, can be measured. However, a realistic pressure drop is 250 pascals (Pa) across flower cartons—adding a safety margin of 25 per cent means there is a required pressure drop of 312.5 Pa.

Multiply volume flow (in cubic metres per hour per carton) by the number of cartons to be cooled. **For flowers, a figure of 150 cubic metres of air per hour per carton can be used multiplied by the number of cartons to be cooled** (for example 30 cartons) gives:

= 150 m^3/h/carton x 30 cartons
= 4500 m^3/h

A 25 per cent safety margin should be added:

= 4500 m^3/h x 1.25
= **5625 m^3/h**

Figure 15.3 shows a typical pressure drop/volume flow relationship for an axial fan with a maximum flow rate of 3800 m^3/h. For a pressure drop of 312.5 Pa, this fan would draw only about 1300 m^3/h.

For our example of 30 cartons, this fan would be insufficient—to overcome this, select a fan with greater capacity or cool fewer cartons at a time.

A reliable supplier of quality fans can assist with choice of equipment. A fan speed controller and a timer will provide a variable flow system that stops when the pre-set cooling period is over. Axial flow (or propeller type) fans are more economical to run than centrifugal fans.

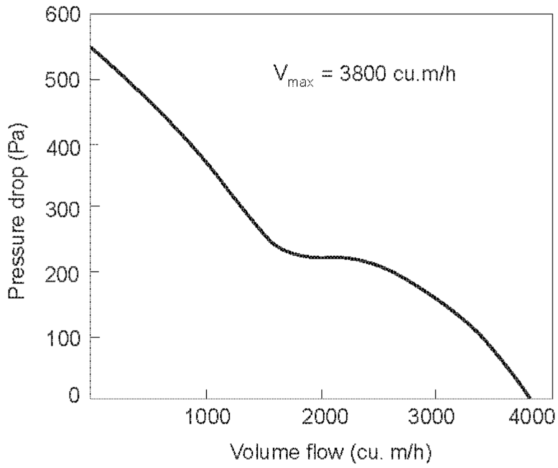


Figure 15.3. Typical pressure drop and volume flow relationship for an axial flow fan

Time of cooling

Pressure cooling systems will cool flowers in 10–80 minutes, provided that a balanced system is designed and that the refrigeration plant has sufficient capacity to remove the heat.

It is generally enough to cool flowers to 87 per cent cool (for example to 2.5 °C for flowers initially at 20 °C which are held in a 0 °C cold room). Beyond 87 per cent cool, only small decreases in temperature are obtained for lengthy increases in cooling time (Figure 15.4).

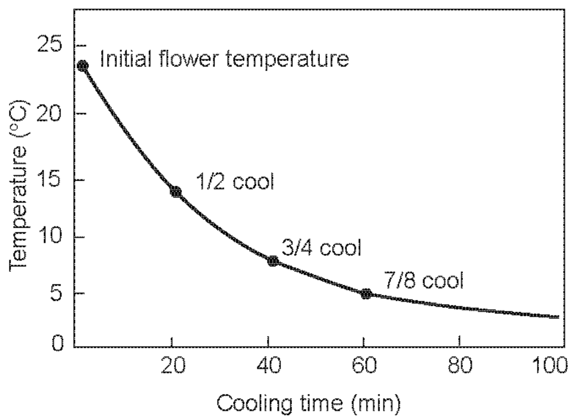


Figure 15.4. Typical pressure cooling curve for cut flowers

From these calculations, you will be able to source a suitable fan to give you the required airflow for your system.

Thanks to Daryl Joyce for his contribution to the early work on cool chain management.

Further reading

Department of Agriculture and Food, Western Australia:

- Farmnote 46/2004 *Cooling cut flowers and foliage.*

Rural Industries Research and Development Corporation:

- Publication series 10/040 *Quality specifications for Australian wildflowers: Pearlflower.*
- Publication series 10/040 *Quality specifications for Australian wildflowers:* W*axflower.*
- Publication 10/027 *Postharvest handling of Australian flowers from Australian native plants and related species* (2^{nd} edition).

16. Storage and transport conditions for waxflowers

Storage and transport essentials

Maintain the cool chain.

Temperature maintained at 1 to 2 °C.

Relative humidity maintained at 95–98%.

Ethylene management in transport and storage.

Refrigerated transport.

Track conditions during transport.

As soon as flowers are harvested they begin to deteriorate. Correct postharvest handling will maximise vase life and maintain flower and foliage quality.

Dehydration is the major factor leading to deterioration of flowers and foliage. It can be minimised by controlling temperature and relative humidity during postharvest storage.

Packaging

Flowers should be packed in boxes or cartons for transport to market. Packaging is important as it protects the flowers during transit and identifies the exporter and his product. It also provides details of flower specifications to freight handlers, importers and others in the supply chain.

The type of packaging materials used can have a huge impact on quality of waxflowers by altering the micro-climate around the flowers.

Cartons

For export, flowers are packed in cardboard cartons—the design of the carton is important and again has an impact on quality. Design considerations should include:

- Ventilation—slots (or holes) allow cool air to be drawn through the flowers. Six per cent of the area of each carton face should be slotted. Slots are better than holes as they are less likely to become blocked.
- Size—different box sizes suit different export markets. Box sizes can typically range from 0.07 to 0.02 m^3. Carton sizes are designed to suit buyer requirements, such as half and quarter cartons for smaller volumes.
- Colour—distinctive carton colours or insignias can help make your product stand out and encourage loyalty
- Specification details need to be clearly marked on the ends of cartons. These need to accurately reflect carton contents (Figure 16.1).

Figure 16.1. Labelling on end of carton showing variety name and generic description with stem number per bunch (on bottom left) and stem length (on bottom right)—ventilation slots are open

Carton liners and bunch sleeves

While most flowers are packed in cardboard cartons, bunch sleeves or carton liners are not recommended as these may affect quality.

The pathway for airflow within the box must not be blocked by carton liners, packaging materials or by flowers being packed too tightly.

Temperature

You need to know optimum storage temperatures for storing flowers. Most temperate crops are not chilling-sensitive and can be stored between 0 and 2 °C for long periods without significant loss of quality.

Produce freezing must be avoided and, because of temperature fluctuations in coolrooms, it is not always safe to set temperatures close to zero.

If possible, harvesting should be in the cool of the day to avoid field heating of flowers. Once flowers are harvested they should be removed from the field and cooled as quickly as possible after processing (see Chapter 15).

Storage recommendations

Storage requirements for many Australian native cut flowers have not been evaluated and since many species are seed grown and genetically variable, results are often inconsistent.

The storage conditions recorded in Table 16.1 are those where no notable adverse effects on quality have been reported in scientific papers and review articles. The table highlights the considerable variation between the storage life of different *Verticordia* and waxflower cultivars and species.

Flowers may need to be dipped in fungicides to prevent damage from diseases during storage.

Relative humidity

High humidity should be used with low temperature storage. Maintaining high humidity (95–98 per cent) around harvested produce reduces water loss. Dehydration greatly affects quality, causing wilting and shrivelling.

Table 16.1. Storage conditions for Australian native cut flowers

Species	Storage period (days)	Temperature (°C)	Initial vase life	Final vase life
Waxflower				
Alba	14–21	1 to 2	9	4
Newmarracarra	7–14	1 to 2	15	14
Purple Pride	7	1 to 2	12	8
Pearlflower				
Laura Mae Pearl⒫	14	1 to 2	24	10
Verticordia				
V. grandiflora	21	1 to 2	13	10
V. monadelpha, *plumosa*	14	1 to 2	13	0
V. nitens	14	1 to 2	7	3

Reducing ethylene in storage and transit

Potassium permanganate

This chemical is commonly sold in sachets for use in small spaces such as cartons of flowers in transit. It is more effective when used to intercept incoming ethylene in cartons, but less effective in removing ethylene produced within the carton due to the very small concentration gradients.

Ozone

Ozone is still largely experimental and is highly reactive—thus difficult to handle. It is also toxic to humans, and direct exposure to plant material is phytotoxic.

Controlled atmosphere (CA) storage

This is used primarily for fruit in Western Australia. CA stores are expensive to construct and the atmosphere inside is lethal to humans therefore there are strict guidelines and procedures to be followed. While beneficial for some ornamental species, the size and structure of the industry does not warrant their use.

Modified atmosphere/active packaging

A number of measures to optimise storage of product while in transit can be used. A range of packaging materials are being trialled and used to varying degrees. These may be active or passive and can help modify gas (carbon dioxide, oxygen, ethylene) levels by different means.

Keeping flowers cool in transit

To keep produce cool, insulated cartons can be used. Icepacks or wrapped dry ice may also be placed inside cartons.

Small temperature loggers are readily available and growers can use these to monitor temperatures in transit to pinpoint problems.

Methods of transport

With the waxflowers cool and stored on-farm under ideal conditions, the next limiting sections of the supply chain are the trucks transporting the product to the exporter, wholesaler or airport.

Many growers now buy second-hand refrigerated trucks to cart their own material. Another option is to make arrangements with refrigerated trucks returning empty from deliveries to regional shopping centres. Many of these travel across all parts of the state. Mutually convenient arrangements can be made to utilise that capacity. Avoid transporting waxflower with ethylene-producing fruit such as apples.

Air transport

There have been experiences of flowers being left on the tarmac at airports in the hot sun for many hours. This will effectively remove any benefit of previous cooling and is likely to increase risk of disease and flower deterioration. Make personal arrangements to ensure either that the flowers are received into a cooled freight facility or are delivered to avoid this delay.

Where possible, identify direct flights or use airlines that have a quality service. International flights are often connecting flights and flowers are off-loaded and transferred to other planes. Occasionally the flowers are left on the tarmac without cooling.

Figure 16.1. The cool chain is interrupted when flowers are loaded at the airport

Sea freight

Sea transport has recently been investigated under simulated conditions in a RIRDC project but does not look to be a promising option at this stage. While vase life was reported to be sufficient after two weeks at 2 °C, there were significant issues with disease after this time.

Tracking conditions during transport and storage

It can be useful to monitor conditions during transit, as this can provide you with information on the maintenance of the cool chain and the expected impact on vase life and quality.

Data loggers can record temperature over time and are small, cheap and easy to use. The data logger is included within a box of flowers, and once recovered at the destination, the information can be downloaded and any temperature variations identified.

There may be methods developed in the future which can measure how long flowers have been stored. This would greatly assist determining the quality of flowers presented at markets.

Importing markets

The further away these markets are the more chance of a breakdown of the cool chain.

However, having good relations with your importer and ensuring they are aware of the benefits of this cool chain will encourage them to work on their end of the chain.

Once the integrity of the cool chain is complete, quality and vase life are maximised. The resulting customer satisfaction helps to build and protect your marketing options.

Further reading

Department of Agriculture and Food, Western Australia:

- Farmnote 46/2004 *Cooling cut flowers and foliage.*
- Farmnote 71/2001 *Storage conditions for ornamental crops.*

Rural Industries Research and Development Corporation:

- Publication series 10/040 *Quality specifications for Australian wildflowers: Pearlflower.*
- Publication series 10/040 *Quality specifications for Australian wildflowers:* W*axflower.*
- Publication 10/027 *Postharvest handling of Australian flowers from Australian native plants and related species* (2nd edition).
- Publication 07/181 *Flowers by sea—improving access for Australian wildflowers*.

17. Exchange rate and waxflower price

Profit and price essentials

Export price depends on the relative exchange rates of the importing country.

Profit in the export trade is sensitive to both the exchange rate and market price.

Price varies according to:
- quality
- variety (premiums)
- demand
- market
- season.

This chapter provides information on the effect of exchange rates and prices, on costs and returns from growing waxflowers. While these figures are meant only to be used as a guide, they highlight some of the main points to aid growers to evaluate and manage the profitability of their enterprise.

Some of the costs associated with getting waxflowers to Japan and the United States are illustrated in Tables 17.1 and 17.2. These should only be used as a guide as they will vary from shipment to shipment and between exporters. Note that while longer stems attract better prices, they are heavier which impacts on freight costs.

Generally the exporters, if they pay a fixed price, carry all the risks associated with cost fluctuations and will need to average out their profit. However, if growers are exporting direct, they carry all the risk and need to be very sure they can cover costs before consigning the product.

It is therefore important to know your cost of production (determined through benchmarking—see Chapter 18) to enable the right decisions to be made.

International and domestic trade

The global flower trade is worth US$8–11 billion wholesale. Australian domestic production of flowers is around A$59 million. Exports of flowers from Australia are worth A$14 million of which 95 per cent are native.

Australia's *Chamelaucium uncinatum* (waxflower) is widely grown as an amenity and potted flowering plant, and is a significant export cut wildflower. The crop is a proven revenue earner and has a high market acceptance.

Waxflowers are Australia's leading commercial native flower and are now in the top 20 flowers in terms of volume sold in Europe. Up to 50 million stems are sold annually on world markets, of which Australia supplies 10 per cent.

There is increasing competition in waxflower production from other southern hemisphere countries such as South America and South Africa, although Australia is well placed to supply markets in South East Asia.

Sensitivity to exchange rates

The export price growers receive for their flowers depends on the relative exchange rates of the country they are trading with. The astute grower or exporter is watching the difference and will decide where they are going to send material.

Tables 17.1 and 17.2 describe the levels of costs associated with exporting. A range of exchange rates are given to demonstrate sensitivity with export costs.

Effects of seasons and exchange rate on profitability

Seasons have a large effect on the price received and exchange rates vary from day to day, so it is difficult to predict the most profitable time of year to export—and this needs to be evaluated constantly (see Figure 17.1). Price is influenced by the quality and quantity of flowers versus demand at the time. High and low prices can be double or half the average.

Selling flowers earlier in the Australian autumn appears to give better prices than in the Australian winter–spring.

This may be due to the mid-year summer holiday season in the northern hemisphere when people are away from home. It may also be because of the abundance of varieties mid-year from Australia and the southern hemisphere during their peak flowering season (Figure 17.2).

Late spring–summer flowers from Australia may see either:

- higher prices due to the lack of flowers from both southern and northern hemispheres at this time, or
- lower prices caused by the availability of cheap flowers from northern hemisphere suppliers in Israel and the United States.

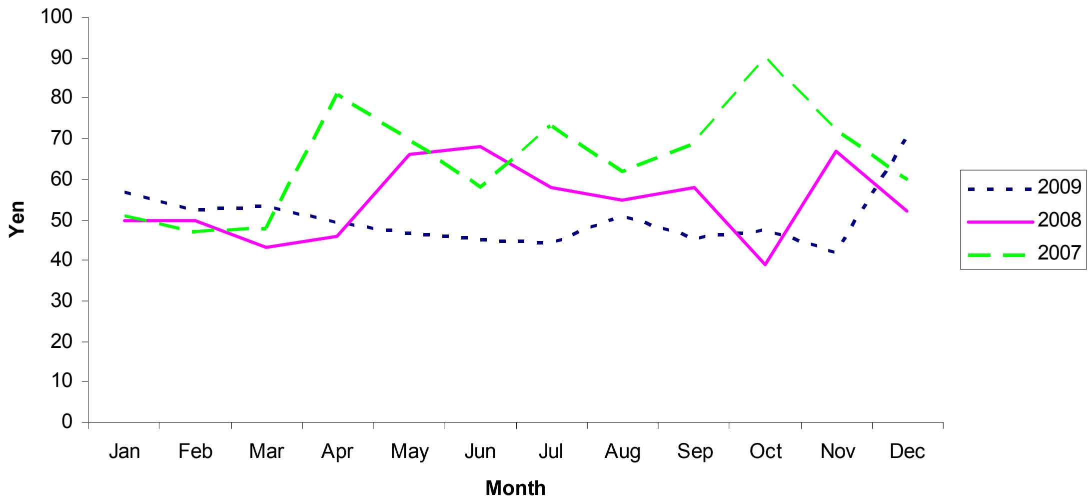


Figure 17.1. Average price per stem of imported waxflowers paid at auction in Japan (2007 to 2009) from online Japanese auction reporting service www.faj.co.jp

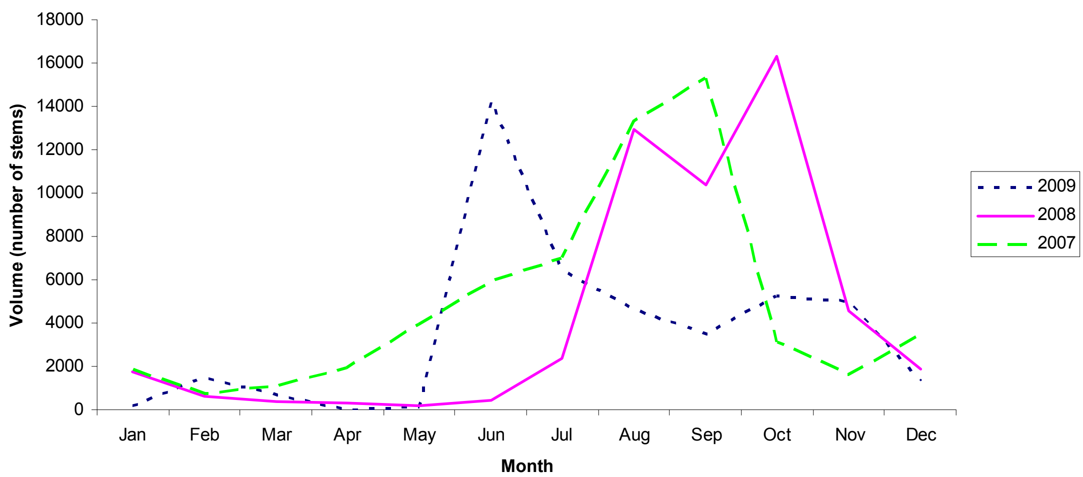


Figure 17.2. Average volume of imported waxflower stems through auction in Japan (2007 to 2009)

Although Table 17.1 is only an example, a similar type of analysis using current figures of track record prices and current exchange rates can be used to determine if a profit can be made. In this example it is not until the Japanese Yen (¥) reaches 60 per Australian dollar (A$) that it is profitable to sell flowers in Japan (see Table 17.1).

Once a profitable price is determined, then growers and exporters should aim, if possible, to negotiate a fixed price that makes selling flowers profitable by seeking out other market options in these countries, or selling flowers in other countries in South East Asia.

Exchange rates have a large effect on the profitability of selling waxflowers in markets such as Japan and the United States. While higher exchange rates make it more profitable to sell flowers, they also increase the price of flowers making them more difficult to sell (Tables 17.1 and 17.2).

Price quality links

Conventional wisdom suggests that better quality flowers receive better prices particularly when targeting quality conscious markets and in times of surplus. Quality may also retain market share and loyalty from buyers.

Buyers tend to rely on a brand name that delivers consistent quality. Once this reputation is achieved, it is paramount to maintain this by rigorously packaging consistent quality.

Quality can be definable but often is not specified. Quality is a combination of:

- stem length
- bunch appearance
- colour
- variety
- percentage of flowers open (usually at least 50 per cent)
- vase life (anti-ethylene treatment).

Quality parameters demanded depend on seasonal availability, and lower ‘quality’ may be accepted and sold in times of shortage. It is not clear how these factors impact on prices paid to growers.

New varieties such as the Pearlflowers have been known to receive significant premiums (up to 25 per cent) particularly early in the season.

As larger volumes of each variety become commercially available, premiums tend to decline. Also, with the introduction of better quality varieties, varieties from previous production will become unsaleable or unprofitable.

Information on price and quality interaction is very limited, however, the Japanese market reports provide some suggestion of variation with reports of high and low prices (Table 17.3). The table would suggest that high quality product can obtain 50–100 per cent premium. Very low quality product can be unsaleable or have a 50–90 per cent discount.

Table 17.1. Effect of exchange rate on costs of exporting waxflowers to Japan

Price per stem at auction (Japan)	¥40 (A$ = ¥68)	¥60 (A$ = ¥68)	¥60 (A$ = ¥78)	¥60 (A$ = ¥88)	¥70 (A$ = ¥78)	¥80 (A$ = ¥78)
Price /10 stems	**$6.76**	**$8.82**	**$7.69**	**$6.82**	**$8.97**	**$10.26**
Auction commission (10%)	$0.60	$0.55	$0.50	$0.75	$0.90	$1.00
Agent in Japan (10%)	$0.60	$0.55	$0.50	$0.75	$0.90	$1.00
Japan internal freight cost (10+%)	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50
Airfreight ($/bunch)	$2.10	$2.10	$2.10	$2.50	$2.50	$2.50
Handling, fumigation and packing	$0.70	$0.70	$0.70	$0.70	$0.70	$0.70
Freight to packing shed	$0.15	$0.15	$0.15	$0.20	$0.20	$0.20
Grower price	$2.20	$2.20	$2.20	$2.40	$2.40	$2.00
Return to exporter	$0.80	$0.80	$0.80	$0.80	$0.80	$0.80
Total costs of supply chain	**$7.65**	**$7.55**	**$7.45**	**$8.60**	**$8.90**	**$8.70**
Profit	(-$0.89)	**$1.27**	**$0.24**	(-$1.78)	**$0.07**	**$1.56**

Note: Freight and price have been adjusted to indicate better prices are generally received from 70 cm stems.

Table 17.2. Effect of exchange rate on costs of exporting waxflowers to the United States

Price per bunch at wholesale (United States)	US$3.50 (A$ = US$0.50)	US$3.50 (A$ = US$0.55)	US$3.50 (A$ = US$0.60)	US$3.50 (A$ = US$0.90)	US$4.95 (A$ = US$0.55)	US$5.60 (A$ = US$0.60)
Price per bunch (12 stems) (AUD$)	**$7.00**	**$8.18**	**$7.50**	**$5.00**	**$9.00**	**$9.33**
Internal US costs (25%)	$1.75	$1.60	$1.45	$1.35	$1.35	$1.35
Airfreight ($/bunch)	$2.00	$2.00	$2.00	$2.00	$2.00	$2.00
Handling, fumigation and packing ($/bunch)	$0.70	$0.70	$0.70	$0.70	$0.70	$0.70
Freight to packing shed from farm	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20
Grower price (fixed price $/bunch)	$2.20	$2.20	$2.20	$2.20	$2.20	$2.20
Exporter allowance	$0.80	$0.80	$0.80	$0.80	$0.80	$0.80
Total costs of supply chain	**$7.65**	**$7.50**	**$7.35**	**$7.25**	**$7.25**	**$7.25**
(Deficit)/Surplus per bunch	(-$0.65)	**$0.68**	**$0.15**	(-$2.25)	**$1.75**	**$2.08**

Table 17.3. Japanese flower auctions (imported waxflower) 2009—representative data for one week in each month (Japanese Yen per stem)

Month	Quantity sold (stems)	High price (¥)	Average price (¥)	Low price (¥)
January	200	60	45	30
February	200	63	55	50
March	300	80	52	45
April	n/a	n/a	n/a	n/a
May	150	225	215	210
June	18,780	75	43	16
July	10,760	70	47	10
August	3557	90	51	15
September	5720	90	49	23
October	5892	80	45	10
November	5650	70	33	10
December	2200	100	25	21

Note: Sourced from Japanese auction price reports at www.faj.co.jp

18. Financial management—benchmarking your enterprise

Benchmarking essentials

Benchmarking tells you how your business is performing and can be used to compare a range of factors such as:

- cost of production ($)
- yield and quality
- performance of different flower varieties or species.

Budgets are calculated to show expected profitability over the life of the crop.

Gross margins allow you to compare the impact of different costs and different prices on returns.

Knowing your cost of production lets you determine what price you need to set to make a profit.

The floriculture industry is seen by many to be a profitable enterprise to get into. Many growers are not sure exactly how profitable they are, as they have not worked out their production costs and have not been able to compare their enterprise with other growers of the same flowers.

It is important to know your cost of production (determined through benchmarking) to enable the right decisions to be made. Ask yourself:

- How much does it cost to harvest, treat, grade and pack your product?
- At what point is it **not** cost effective to harvest low quality waxflowers—is it $1.40 per bunch?
- How can costs be reduced without cutting corners and producing a product that is not up to the required quality?
- How much do you need to return to provide cash flow as well as profit?
- Are other growers producing product at a lower cost per bunch and able to make a profit at $1.00?
- What are your costs and when do you **not** harvest or deliver to the exporter or wholesaler?

Obtaining a small return below cost may be warranted if you are promoting your brand, keeping faith with your buyer, keeping staff employed or need cash flow for your bank.

Setting up a budget and determining cost of production will show your cash flow and allow for forward planning.

Benchmarking is a great tool that allows growers to compare the performance of different enterprises.

Benchmarking

Benchmarking can be done at different levels. It can be done on a total enterprise basis including costs of production, or on production parameters such as yield and quality, or even on the economic factors.

Most benchmarking programs are set up to ensure all grower information remains confidential. Participants are listed by number only, and are able to identify their own production information in tables comparing participants' data. This enables them to compare performance and identify any areas for improvement.

New entrants into the industry would find these tables useful, benefiting from the gross margins and development budgets as examples.

Gross margins and budgets

Gross margins are simple economic calculations comparing operating costs and returns from sales or profits—they don't normally contain taxation or depreciation allowances. Gross margins are only calculated on an annual basis.

Development budgets are calculated over the life of a crop and include depreciation allowances in most cases. They also allow calculation of cash flow and peak debt over that time.

The cost of growing flowers

The cost of producing flowers consists of the capital costs of establishment, direct costs of running the business and indirect costs associated with running any enterprise (Table 18.1).

Table 18.1. Flower production costs

Capital costs	Direct costs (variable)	Indirect costs (overheads)
Land and fixtures	**Planting materials**	**Overheads**
The land Dams and bores Fencing	Seeds Cuttings	Rates/taxes, Phones, Account fees Soil testing Promotion Delivery
Structures	**Chemicals**	
Greenhouses Shade houses Packing sheds Chemical sheds Coolrooms	Fungicides Insecticides Fumigants Disinfectants	
Machinery/vehicles	**Fertiliser**	
Tractors, Rotary hoe Grader, Trailer Bunch tying machine Delivery van	Trace elements Lime Liquid fertiliser Bulk fertiliser	
Equipment	**Labour**	
Spray equipment Irrigation systems Drainage parts Water disinfestation equipment Disc plough Fertiliser spreader Fertigation unit	Planting Harvest Postharvest	

Capital costs

Capital costs include land and water, structures (such as buildings and sheds), machinery, vehicles (tractors etc) and equipment such as graders and ploughs.

Direct costs

These are costs directly associated with the production of the crop and are generally the ones used in calculating gross margins.

These costs are generally in direct proportion to the amount of crop grown. This, however, may be different if you have full-time staff you wish to keep on.

Indirect costs

These are costs associated with running a business and are not dependent on the area of crop grown.

Environmental costs

Most growers don't factor environmental impacts into their production costs, but this will be necessary when growers begin to market under eco-labels—there is a cost to managing environmental consequences of production.

Social cost

Social costs are those that impact on your family or your leisure activities (or lack thereof), and may also include the impact of changing production area on the careers of family members.

Natural resource cost

The natural resource cost in the flower industry may refer to the loss of biodiversity or nutrient loss from harvest.

Income

Business income is directly related to the quantity, quality and price received for product, less the charges from selling agents and transport. In the flower industry this is calculated on a per stem basis or whole enterprise basis.

The gross margin is generally the net income minus direct costs. Business profitability is based on the total income minus the total costs including taxation.

Budgeting for a new or extended waxflower enterprise

Development budgets allow managers to determine the likely profitability and the peak cash flow needs of an enterprise.

These budgets allow for the costing of land, machinery, land clearing and development, establishment of irrigation systems and sheds, planting and management costs—incorporating the progressive increase in yields in the first few years and decline in later years. The middle years may be considered a 'typical' year-in year-out cost structure (in a normal situation) closely aligned to a gross margin budget.

The development budget may involve a sensitivity analysis on inputs to determine risk. This allows you to see what impact any changes (for example, a drop in price per bunch) may have on cash flow.

The scale of the enterprise can also have a significant impact on cash flow. A 1 ha waxflower enterprise cannot hope to cover a fully-equipped packing shed. While a 200 ha enterprise can certainly cover such costs, the volume produced may impact on prices received on specific markets if the varieties are all the same. Splitting your crop into manageable modules allows better management and logistics. Matching scale with shed capacity, trucks, labour and water supply are all considerations that need to be explored.

Published development budgets, such as this one, should only be used as a guide. Each property and enterprise is different, and development budgets vary markedly to reflect this. Always discuss budgets with your financial consultant.

Table 18.2 (extracted from Miscellaneous Publication 19/2005 *Improving profit in the flower growing business*) works on the assumption that a 10 ha enterprise is viable. All data are examples only provided as a framework to show how to set out a budget for your own situation.

The example shows the enterprise development over four years to spread risk, work load and cost.

Year 7 can be considered a gross margin or steady state situation. Year 6 is the break even year when cash flow is positive. The other important feature is the life of the plantation. The budget in Table 18.2 shows a run-down in yield towards the end of the project. In most situations, growers plan an ongoing enterprise and would need to budget for replanting at least 10 per cent per year, starting in year 5 or 6. Rather than replanting individual plants among older plants—it is more practical to establish new areas.

Project evaluation using net present value and benefit cost ratio

While the development budget provides a guide to the income and costs over the lifetime of the project, the discounted cash flow and net present value (see Table 18.3) provide a method to evaluate your investment in a waxflower project.

The net present value (NPV) provides a net value of cash flows (total income minus total expenses) in today's dollar value (present value). Projects should only be selected where the NPV is positive and benefit cost ratio (BCR) is greater than 1. The method of calculation for the BCR is:

$$BCR = \frac{\text{present value of net cash flows}}{\text{initial cash outlay}}$$

The NPV and BCR in the example budget provided are $543,000 and 1.81 respectively, indicating that it is a worthwhile project to undertake.

Caution should be applied when using BCRs in isolation because a project may have a higher BCR in comparison to another project but with a lower NPV. The project returning the highest NPV should be the preferred option for investment purposes.

Interpreting a gross margin

In Table 18.4, the income section shows the area of the enterprise, the number of stems per hectare and the breakdown of product grades with appropriate prices. The total income is then calculated.

Table 18.4. Example gross margin budget for waxflowers

Waxflower			Gross margin
Income			
Total area (hectare)			10
Average bunch per hectare			20,000
Total production			200,000
Average price per bunch			$2.11
Grade 1	$2.50	20%	$110,000
Grade 2	$2.00	70%	$280,000
Grade 3	$1.50	10%	$30,000
Total income			**$422,000**
Costs of production			
Land preparation			$200
Replacement plants 10%			$3,000
Pruning			$600
Weed control			$4,500
Disease control			$5,620
Insect control			$1,240
Tissue/soil test			$600
Fertiliser			$770
Irrigation			$10,000
Fuel			$6,000
Harvest/postharvest			$128,000
Miscellaneous			$2,000
Total cost			**$162,530**
Gross margin			**$247,470**
Gross margin per hectare			**$24,747**

Note: This gross margin example is included as a guide only. Individual growers will need to discuss this with their financial advisers or accountants.

You will notice that all the costs are those of the annual production cycle for the particular crop and do not include development costs, depreciation, indirect costs, environmental costs and taxation.

This example indicates the grower is replanting 10 per cent of the crop on an annual basis, either with new varieties or to fill gaps. The costs have been broken down into supplies and labour.

Some operations are carried out in conjunction with others and do not incur extra costs, such as if insect control is carried out at the same time as disease control. The flower industry is a heavy user of labour. Mechanisation of some parts of the production chain, particularly on larger scale operations, can make significant differences to profitability.

The total costs are added up. The gross margin is the difference between the income and the costs.

This can be expressed as enterprise gross margin but is more often converted to a hectare basis for comparison purposes.

Gross margins allow for a quick comparison of the profitability of different enterprises or course changes to an enterprise. However, determining the real cost of the enterprise requires a more complex cash flow or development budget.

Benchmarking your business

Benchmarking is often used in business management. It is an ongoing process that helps assess best practice or performance at a point in time. New best practice is then introduced to improve performance that then sets a new benchmark.

The technique can be used for any set of performance criteria ranging from production through to environmental impact.

Benchmarking is often used in agricultural industries to compare the performance of different growers producing the same product. This can be based on physical production inputs, yield and cost.

The benchmarking process itself does not improve performance, but it does highlight various aspects where improvements can be made.

Table 18.2. Example developmental budget for a waxflower enterprise (extracted from Miscellaneous Publication 19/2005 'Improving profit in the flower growing business')

Incremental cash flow for a waxflower enterprise

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13
INCOME $													
Total enterprise area (ha)	2.5	5.0	7.5	10.0	10.0	10.0	10.0	10.0	10.0	10.0	7.5	5.0	2.5
Total production (number bunches)	0	8,750	30,000	80,000	130,000	171,250	200,000	200,000	200,000	200,000	150,000	100,000	50,000
Average price received ($/bunch)		2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11
Income ($/bunch x number of bunches)													
Export Grade 1	0	4,900	16,800	44,800	72,800	95,950	112,000	112,000	112,000	112,000	84,000	56,000	28,000
Export Grade 2	0	12,250	42,000	112,000	182,000	239,750	280,000	280,000	280,000	280,000	210,000	140,000	70,000
Export Grade 3	0	1,313	4,500	12,000	19,500	25,688	30,000	30,000	30,000	30,000	22,500	15,000	7,500
ANNUAL TOTAL BUSINESS INCOME	**0**	**18,463**	**63,300**	**168,800**	**274,300**	**361,388**	**422,000**	**422,000**	**422,000**	**422,000**	**316,500**	**211,000**	**105,500**
ANNUAL TOTAL BUSINESS INCOME PER HA	**0**	**3,693**	**8,440**	**16,880**	**27,430**	**36,139**	**42,200**	**42,200**	**42,200**	**42,200**	**42,200**	**42,200**	**42,200**
Improved value of assets													50,035
EXPENSES $													
Development expenses													
Land preparation	1,983	1,983	1,983	1,983									
Marking out and survey	750	750	750	750									
Ripping, deep fertilising	478	478	478	478									
Plants and planting	9,583	9,583	9,583	9,583									
Miscellaneous site development costs	1,250	1,250	1,250	1,250									
Irrigation	57,932	40,963	57,632	40,963									
Plant and machinery	19,622	9,330	17,282	600	600	600	2,280	600	3,720	600	600	600	2,280
Annual total development expenses	**91,598**	**64,337**	**88,958**	**55,607**	**600**	**600**	**2,280**	**600**	**3,720**	**600**	**600**	**600**	**2,280**
Operating expenses													
Pruning	188	263	375	525	488	563	600	600	600	600	450	300	150
Training	0	0	0	0	0	0	0	0	0	0	0	0	0
Weed control	0	1,038	2,163	3,288	4,413	4,500	4,500	4,500	4,500	4,500	3,375	2,250	1,125
Disease control	0	1,281	2,636	4,058	5,479	5,619	5,686	5,685	5,685	5,685	4,264	2,843	1,421
Insect control	0	310	620	930	1,240	1,240	1,240	1,240	1,240	1,240	930	620	310
Tissue and soil analyses	400	600	600	600	600	600	600	600	600	600	600	600	600
Fertiliser	0	478	670	862	1,053	767	767	767	767	767	575	384	192
Irrigation maintenance (labour)	1,250	2,500	3,750	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,750	2,500	1,250
Harvest, postharvest, packaging and transport	0	7,290	20,951	53,095	85,239	110,092	128,575	128,575	128,575	128,575	96,431	64,288	32,144
Fuel and oil (including irrigation)	2,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Repairs and maintenance (plant)	2,100	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Electricity (including irrigation)	2,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Rates	400	400	400	400	400	400	400	400	400	400	400	400	400
Licences, phone, internet, subs	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
Insurance	1,500	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Accountant	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
Manager and consultant	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000
Miscellaneous expenses	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Replants	0	1,971	383	0	0	0	0	0	0	0	0	0	0
Overdraft interest	557	1,232	1,644	2,549	3,428	4,050	4,514	4,514	4,514	4,514	3,599	2,685	1,770
Annual total operating expenses	**22,595**	**49,563**	**66,392**	**103,507**	**139,540**	**165,031**	**184,082**	**184,081**	**184,081**	**184,081**	**146,574**	**109,070**	**71,562**
ANNUAL TOTAL EXPENSES (operating & devel.)	**114,193**	**113,900**	**155,350**	**159,114**	**140,140**	**165,631**	**186,362**	**184,681**	**187,801**	**184,681**	**147,174**	**109,670**	**73,842**
ANNUAL TOTAL EXPENSES PER HA	**45,677**	**22,780**	**20,713**	**15,911**	**14,014**	**16,563**	**18,636**	**18,468**	**18,780**	**18,468**	**19,623**	**21,934**	**29,537**
ANNUAL CASH FLOW $													
TOTAL (pre tax)	-$114,193	-$95,437	-$92,050	**$9,686**	**$134,160**	**$195,757**	**$235,638**	**$237,319**	**$234,199**	**$237,319**	**$169,326**	**$101,330**	**$31,658**
TOTAL CASHFLOW PER HA	-$45,677	-$19,087	-$12,273	**$969**	**$13,416**	**$19,576**	**$23,564**	**$23,732**	**$23,420**	**$23,732**	**$22,577**	**$20,266**	**$12,663**
CUMULATIVE TOTAL (pre tax)	-$114,193	-$209,630	-$301,680	-$291,994	-$157,834	**$37,923**	**$273,561**	**$510,880**	**$745,079**	**$982,398**	**$1,151,724**	**$1,253,054**	**$1,284,712**

Table 18.3. Benefit cost analysis for a waxflower enterprise based on the developmental budget in Table 18.2

Discounted cash flow

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13
INCOME $													
Export Grade 1		4,900	16,800	44,800	72,800	95,950	112,000	112,000	112,000	112,000	84,000	56,000	28,000
Export Grade 2		12,250	42,000	112,000	182,000	239,750	280,000	280,000	280,000	280,000	210,000	140,000	70,000
Export Grade 3		1,313	4,500	12,000	19,500	25,688	30,000	30,000	30,000	30,000	22,500	15,000	7,500
ANNUAL TOTAL BUSINESS INCOME	**0**	**18,463**	**63,300**	**168,800**	**274,300**	**361,388**	**422,000**	**422,000**	**422,000**	**422,000**	**316,500**	**211,000**	**105,500**
EXPENSES $													
Annual total development expenses	91,598	64,337	88,958	55,607	600	600	2,280	600	3,720	600	600	600	2,280
Annual total operating expenses (minus interest)	22,038	48,331	64,748	100,958	136,112	160,981	179,568	179,567	179,567	179,567	142,975	106,385	69,792
ANNUAL TOTAL EXPENSES	**113,636**	**112,668**	**153,706**	**156,565**	**136,712**	**161,581**	**181,848**	**180,167**	**183,287**	**180,167**	**143,575**	**106,985**	**72,072**
NET CASH FLOW	-$113,636	-$94,205	-$90,406	**$12,235**	**$137,588**	**$199,807**	**$240,152**	**$241,833**	**$238,713**	**$241,833**	**$172,925**	**$104,015**	**$33,428**

Discount rate	7.50%	*The opportunity cost of capital*
Present Value Income	$1,942,570	*sum of all income, years 1 to 13, in real terms (adjusted for inflation)*
Present Value Costs	$1,263,777	*sum of all costs, years 1 to 13, in real terms (adjusted for inflation)*
Net Present Value	$678,794	
Benefit Cost Ratio	**2.26**	*BCR greater than 1 indicates a project will have positive returns (a ratio of 2.26 means a return of $2.26 for each $1.00 invested)*
Internal Rate of Return	21.67%	
Pay Back Period	5 years	

Notes:

Discount rate *is the required rate of return that a project must generate in order to justify raising funds to undertake it. Where there is perfect certainty about the outcome of an investment, the risk-free rate, such as the current yield on government securities of the same maturity as the investment, is the appropriate discount rate. However, where there is uncertainty about the outcome of the investment, a risk adjusted required rate of return must be used.*

Present value *is the cash equivalent today of an amount to be paid or received at some future time. It is typically calculated by discovering future cash flows at a required rate of return.*

Benefit cost ratio *is an investment calculation for analysing profitability of projects. It asks the question 'whether the benefits exceed the costs over the life of the investment after the time value of money has been taken into account?' A ratio greater than 1 is a profitable project.*

Internal rate of return *is the discount rate which equates present value of a project's net cash flows to the initial outlay on that project. It is the discount rate at which net present value is equal to zero.*

To retain confidentiality in a group situation, a third party often carries out the calculations and tabulations. There are many ways to benchmark—some systems include software but others are carried out manually.

Growers provide information on

- the area planted
- equipment running time
- labour costs at each stage
- fertiliser type, quantity and cost
- pesticide type quantity and cost
- irrigation quantities, timing, amounts and cost of running the system
- harvesting labour cost
- harvesting supplies and their cost
- postharvest labour and equipment
- packaging cost
- disinfectant quantity and cost
- coolroom cost
- transport cost
- marketing cost
- yield and grades
- prices received.

The results are then presented in different ways—usually tables or graphs.

Benchmarking example

An example benchmark (Table 18.5) illustrates some of the features and benefits of using this technique. The area planted and the crop age are assumed to be the same.

In Table 18.5, five hypothetical waxflower farms are compared. The large variation in total income for the different farms, depends heavily on the yield and grade of stems produced. For all farms, prices have been kept the same for each grade.

Farm 2 makes almost twice as much as Farm 1, the increased profit due to higher yield and greater proportion of grade 1 stems.

Although field management costs went up for Farm 2—with more spent on insect and disease control, tissue testing and fertiliser, but less on irrigation for the same number of plants—they were still more profitable.

Profitability is more likely in farms that manage the plant water balance well—using fertiliser rates based on soil/leaf tissue tests and using tensiometers to monitor irrigation (see Chapter 6 and 7 on Irrigation and Nutrition). Farm 2 also spent an extra $2000 on postharvest packing and grading stems to produce more high quality stems.

The yield of Farm 4 was half that of Farm 1, but production costs were similar. Poor management practices on Farm 4 (such as no replanting to fill gaps, inefficient watering and nutrition systems, as well as poor grading operations) have resulted in poor yields and lower quality. This has lead to a dramatic difference in gross margins between the two. Higher yields and better quality can be achieved by replanting with high quality plants of selected varieties.

Farm 5 and Farm 1 carry out the same level operations but not at the same level as Farm 2. Farm 1 devotes more time to postharvest labour; ensuring lines are uniform in length and form as well as grading by colour. The result is more grade 1 product.

Farm 3 has less return on the two hectares compared to Farm 5 due to lower yield as a result of inefficiencies in fertiliser application and postharvest operations.

The comparison between different farms is a powerful tool to enable improvement in your own enterprise. Identify your strengths and weaknesses and focus on those areas in which can have the greatest impact on your profitability.

Moving to a more efficient system of irrigation and fertiliser application can result in a 30 to 40 per cent yield increase, as well as improving quality and vase life.

Table 18.5. Example benchmarking table comparing five growers

Waxflower	Farm 1		Farm 2		Farm 3		Farm 4		Farm 5		Average	
Income												
Total area (hectare)	2		2		2		2		2		2	
Stems/plant	60		100		50		30		60		60	
Average number bunch/ha	12,000		20,000		10,000		6,000		12,000		12,000	
Total production (bunch/ha)	24,000		40,000		20,000		12,000		24,000		24,000	
Grade 1 Proportion 60%	60%		70%		50%		50%		50%		56%	
Grade 2 Proportion 30%	30%		20%		35%		30%		30%		31%	
Grade 3 Proportion 10%	10%		10%		15%		20%		15%		13%	
Grade 1 $2.50/bunch		$36,000		$70,000		$25,000		$15,000		$30,000		$35,200
Grade 2 $2.00/bunch		$18,000		$20,000		$17,500		$9,000		$18,000		$17,700
Grade 3 $1.50/bunch		$6,000		$10,000		$7,500		$6,000		$9,000		$7,100
Total income		**$60,000**		**$100,000**		**$50,000**		**$30,000**		**$57,000**		**$60,000**
Cost of production	**Supplies**	**Labour**	**Supplies**	**Labour**	**Supplies**	**Labour**	**Supplies**	**Labour**	**Supplies**	**Labour**	**Supplies**	**Labour**
Land preparation		90		90		90		0		90	0	72
Replacement plants planted 10%	350	40	450	40	350	40	0	0	350	40	300	32
Pruning		160		220		160		160		160	0	172
Weed control	150	150	150	150	150	150	150	150	150	150	150	150
Disease control	80	100	120	120	80	100	80	100	80	100	88	104
Insect control	40	0	80	20	40	0	40	0	40	0	48	4
Tissue/soil test	150	50	150	50	0	0	150	50	150	50	120	40
Fertiliser	450	150	500	150	800	150	450	150	450	150	530	150
Irrigation		500		400		600		500		500	0	500
Fuel	1,000		800		1,200		1,000		1,000		1,000	0
Harvest/postharvest	1,000	14,000	1,000	16,000	1,000	18,000	1,000	14,000	1,000	13,000	1,000	15,200
Costs	$3,220	$15,240	$3,250	$17,240	$3,620	$19,290	$2,870	$15,110	$3,220	$14,240	$3,236	$16,424
Total cost		**$18,460**		**$20,490**		**$22,910**		**$17,980**		**$17,460**		**$19,660**
Gross margin		$41,540		$79,510		$27,090		$12,020		$39,540		$40,340
Gross margin/ha		**$20,770**		**$39,755**		**$13,545**		**$6,010**		**$19,770**		**$20,170**

Benchmarking: the next step

Real farm comparisons would include more detail and would analyse a wider range of practices to determine which ones could be introduced or refined.

The checklist included in this section will indicate if you are collecting sufficient information to be able to conduct a useful benchmarking activity.

Commercial consultants and financial advisers are in a good position to help growers on individual basis. They may also be in the position to conduct a comparison with other clients.

The Flower Association of Queensland Inc (FAQI) has developed a computer program *Cut Flowers and Foliage Whole Farm Economic Decision Calculator* which can be requested from their website at **www.flowersqueensland.asn.au**

The benefits

The benefits of benchmarking your enterprise are clear. Growers are likely to increase their profitability, productivity and the quality of their product.

Banks normally require some indication of gross margins, but will also need cash flow budgets.

Further reading

Carson C and Beal P (2000) *Should I grow wildflowers?* Department of Primary Industries and Fisheries, Queensland.

Department of Agriculture and Food, Western Australia:

- Miscellaneous Publication 19/2005 *Improving profit in the flower growing business.*

19. Waxflower industry contacts, links and references

Inquiries

Department of Agriculture and Food, Western Australia

For further information on waxflowers

Tel (08) 9368 3333
Email: enquiries@agric.wa.gov.au
Web: **www.agric.wa.gov.au**

Grower groups

Wildflower Growers of Western Australia is a grower-run body in Western Australia. Contact the Department of Agriculture and Food, Western Australia for details.

Nursery and Garden Industry of Western Australia (NGIWA) conducts many training events for the nursery and garden industry.
NGIWA
2 Somersby Rd, Welshpool WA 6106.
Tel: (08) 9358 4811
Email: reception@ngiwa.com.au
Web: **www.ngiwa.com.au**

WildFlowers Australia is the peak national body for the floriculture industry in Australia with members from the whole floriculture supply chain.
Tel: (07) 5494 4935
Email:
management@wildflowersaustralia.com.au
Web:
www.wildflowersaustralia.com.au

Websites

Department of Agriculture and Food, Western Australia
www.agric.wa.gov.au —click on horticulture and select 'floriculture and nursery'

Department of Employment, Economic Development and Innovation, Queensland (Primary Industries and Fisheries) **www.dpi.qld.gov.au** —search for 'flowers'

NSW Department of Industry and Investment (Primary Industries—Agriculture) **www.dpi.nsw.gov.au** —click on 'f' for flowers

WildFlowers Australia
www.wildflowersaustralia.com.au

Flower Association of Queensland Inc. (FAQI) **www.flowersqueensland.asn.au**

Flowers Victoria
www.flowersvic.com.au

Rural Industries Research and Development Corporation (RIRDC) funds research in Australian native flowers—their website contains many reports, some of which are referred to in this bulletin: **www.rirdc.gov.au**

Department of Environment and Conservation (formerly CALM)—flora, plants and licences: **www.dec.wa.gov.au**

Recommended reading

Should I grow wildflowers (2000) by Carson C and Beal P. Department of Primary Industries and Fisheries, Queensland.

Wildflowers—the beginning by Slater T and Faragher J. Department of Primary Industries Victoria.

Growing wildflowers for profit by Cass A, Slater T and Tregea W. Department of Primary Industries Victoria.

Getting started in native flower production by Gollnow B. (January 1999) NSW Agriculture (2nd edition).

Industry magazines

Australian Flower Industry Magazine is quarterly with a national perspective on cut flower and foliage production and the florist industry. It is produced by the Flower Association of Queensland Inc. PO Box 327, Cleveland, QLD 4163
Email faqi@flowersqueensland.com.au

Horticulture Australia by Agricultural Publishers Pty Ltd is published monthly. It contains general information on broad range of topics, including floriculture.
Web: **www.ruralpress.com** click on magazines then *Australian Horticulture*

Information services

GrowSearch conducts fee-for-service information searches. They hold a very large database of information, much of it relevant to floriculture. An annual fee of about $110 covers your topic search.

GrowSearch can be contacted at
PO Box 327, Cleveland QLD 4163.
Tel: (07) 3824 9555
Email growsearch@dpi.qld.gov.au
Web: **www.dpi.qld.gov.au** and search for 'growsearch'

Further reading on CD

Department of Agriculture and Food, Western Australia publications

Bulletins:

4683 *Sampling and testing for plant pathogens*

4682 *Phytophthora diseases of cut flower crops*

4583 *Diseases of waxflower and their control*

4512 *Fertigation of vegetables in Western Australia*

Farmnotes:

395 *Pests of export wildflowers*

394 *Postharvest insect disinfestation treatments for cut flowers and foliage*

333 *Selecting the right pump for an irrigation system*

332 *Different pumps for irrigation systems*

301 *Preparation of liquid fertiliser stock solutions*

276 *What should I use to measure soil moisture*

234 *Water salinity and plant irrigation*

198 *Calculating readily available water*

196 *Converting readily available water to litres for drip systems*

68/2004 *Tensiometers preparation and installation*

47/2004 *Flowers giving the market what it wants*

46/2004 *Cooling cut flowers and foliage*

59/2003 *Fertilisers for waxflower production*

45/2003 *Commercial cut flower growing is it for you*

40/2003 *Insect control of waxflowers*

72/2002 *Using windbreaks to reduce evaporation from farm dams*

03/2002 *Irrigation of native cut flowers*

71/2001 *Storage conditions for ornamental crops*

35/2001 *Selection of fertigation equipment*

43/99 *Windbreaks for horticulture on the Swan Coastal Plain*

108/94 *Disinfestation of wildflowers using insecticide dips*

79/94 *Soil moisture sensors for sandy soils*

48/92 *Efficiency of sprinkler irrigation systems*

41/90 *Blockages in irrigation lines*

35/90 *Evaluating sprinkler and trickle irrigation systems*

26/90 *Soil moisture monitoring equipment*

24/90 *Interpreting tensiometer readings*

23/90 *Irrigation scheduling how and why*

22/90 *Scheduling for trickle, sprinkler and flood irrigation*

Miscellaneous publication:

MP 19/2005 *Improving profit in the flower growing business*

Resource Management Technical Report:

65 *Evaporation data for Western Australia*

Using flowers series:

Pearlflower

Purple Gem

Southern Stars

1. Production

Know your flower marketing options.
Quality control—ensure you have:
- appropriate variety selection
- effective irrigation and nutrition
- insect- and disease-free plants
- optimal time/ timing of picking
- correct postharvest handling (harvesting, temperature control, anti-ethylene treatments)
- good presentation of final product.

Set the scale of your enterprise.
Obtain relevant licences (planning approval, native flora commercial producers licence, water allocations).
Crop monitoring can save you money and lift crop quality:
- soil and tissue testing
- tensiometers for optimal irrigation scheduling.

Business planning, benchmarking and record keeping will help you keep track of production and quality.
Flex your business to market conditions.

2. Quality

Quality control is impacted right through the supply chain (variety selection, nutrition and irrigation, pest and disease control, anti-ethylene treatments, cool chain management, export-import requirements).
Know the quality parameters required (flowering stage, stem length, bunch weight).
Develop a feedback loop along supply chain to monitor quality.

3. Variety selection

Talk to your buyer–what do they need?
Does the variety:
- meet current market demands
- meet future predictions for market trends and demands
- suit your growing conditions
- complement your other varieties in terms of agronomics (fertiliser & irrigation requirements)
- complement your other varieties in terms of colour
- complement your other varieties and crops in terms of seasonality (picking time).

4. Establishment

Site selection and preparation:
- northerly aspect to site
- low frost risk—areas up-slope
- low soil P (less than 20 ppm)
- well drained soil—pH 5.5 to 6.5
- soil free from weeds/disease.

Design and install irrigation/fertigation:
- use trickle irrigation/microsprinklers
- budget water resources for current and future requirements
- do a full test run to make sure the system works before planting.

Select and order your tube stock:
- set a planting date
- order your tube stock ahead of the planting date (3 months)
- avoid using old tubestock (between 3 and 6 months old)
- aim for planting in warmer weather for optimum growth.

Establish windbreaks.
Planting tubestock:
- prepare for planting well before plants arrive (deep ripping, weed control, compost)
- wet up soil a week before planting
- examine tubestock on arrival
- discard (return) any root bound, top-heavy, pale or diseased plants
- plant out seedlings within 2 weeks of arrival.

Plant in single rows:
- north–south oriented rows
- 1–2 m intra-row spacing
- 3–4 m between rows (allow vehicle access).

Management of plants in-ground:
- avoid planting in heat-wave conditions
- install individual wind guards for seedlings
- remove wind guards after 3 months
- weed by hand around young plants
- prune by 30–50% height (after 6 months) to set up optimum canopy shape for max. production
- apply slow release fertiliser for first 6 months
- at 6 months, gradually introduce fertigation—apply one third of the recommended rate weekly, then increase the frequency to every second day.

5. Pruning

Prune young plants:
- by hand in the first year
- when they reach 300 mm high
- cut back to 120–150 mm high.

Do not prune below 120 mm.
Prune mature plants:
- initially to 450 mm in height and then side prune at 60 degrees
- subsequently to 5–10 cm above the last pruning height.

Time your pruning:
- at or straight after harvest for maximum yield and stem length
- to avoid hot weather.

6. Irrigation

Waxflowers respond to irrigation.
Irrigation is critical to stem length, yield and quality and:
- is essential during summer (main period of growth)
- ensures maximum stem length
- avoids crop stress
- is essential for fertigation.

Schedule your crop water needs.
Water use varies with:
- time of year
- farm location and soil type
- evaporation rate
- variety
- stage of growth
- timing of pruning.

Install soil moisture probes (tensiometers) to:
- monitor crop water use
- calculate irrigation frequency.

Determine type of irrigation system and design an irrigation system to cope with the water needs of your farm.
Assess your water quality.

7. Nutrition

Waxflower requires small frequent doses of balanced fertilisers (kg/ha/y):

Nitrogen (N)	150
Potassium (K)	115
Phosphorus (P)	7
Calcium (Ca)	8
Magnesium (Mg)	6
Sulfur (S)	10
Trace elements	0.2

* Vary amounts of fertiliser for each season and by plant age & density.

Fertiliser is best applied by fertigation through drippers (topdressing may be suitable in some rainfall zones).
Soil pH can affect nutrient uptake.
- high pH (>7) binds Fe, Mn, Cu, Zn
- low pH (<5) binds P, Ca, Mg.

Calculate kg fertiliser/ha according to:
- age of plants
- varietal requirements
- planting densities.

Nutrient sampling can help fine-tune your fertiliser regime. Monitor nutrient status of your crop with:
- soil tests (especially P levels and pH—ideally 5.5 to 6.5)
- leaf colour checks and tissue testing of young leaves after summer growth.

Make up a stock tank for fertigation to:
- supply a given number of plants
- cater for seasonal requirements.

Adjust injection rate according to:
- age of plants
- variety of plants
- season.

8. Insect control

Biosecurity—inspect all plant material entering your property.
Monitor your crop regularly in the field:
- highest risk September–March
- set up sticky traps
- sample flowers in the field.

Integrate field control and postharvest disinfestation treatments. Maintain crop hygiene, remove infected plant material from the base of plants after harvest and pruning.

9. Disease control

Biosecurity plan in place to prevent diseases entering your property on vehicles, machinery or plant material.
Crop hygiene:
- remove/destroy pruning waste.

Soil conditions:
- prevent waterlogging
- balanced fertiliser applications (too high or too low can make plants more prone to disease).

Monitor your crop for signs of:
- foliar disease—*Botrytis*, powdery mildew, *Alternaria*.
- soilborne disease—*Armillaria Pythium*, *Phytophthora*, rots, *Rhizoctonia* and nematodes.

10. Weed control

Biosecurity plan in place to prevent weed seeds entering your property on vehicles, machinery or plant material.
Site preparation BEFORE planting will minimise weed seedbank.
Weed control is most critical at crop establishment (competition).
Integrated weed control is a practical approach—use a combination of:
- cultivation
- handweeding
- herbicides
- mulches
- inter-row cover crops.

11. Harvesting

Ensure that you:
- have enough labour available to harvest & pack stems
- know your variety specifications (stage of picking, stem length etc.)
- set up your packing shed to handle predicted quantity of stems.

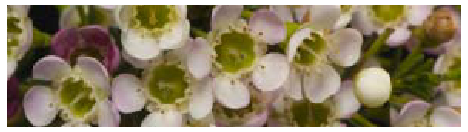
Set your harvest schedule.
Choose your harvesting process—bunch in the field, or cut and bunch in the shed.
Keep a record of the season's harvest for comparison.

12. Postharvest ethylene management

Waxflowers are very sensitive to ethylene.
Ethylene causes flower drop and is produced by:
- flowers & plants under stress
- fruit & vegetables
- machinery exhaust fumes.

Flowers need protection from ethylene:
- before harvest—regular spraying for *Botrytis* once flowers start to open in the field
- postharvest—continuing in the shed with fungicide dips.

Use one of the following anti-ethylene treatments to protect flowers:
- quick pulse in STS
- overnight pulse in STS
- 1-MCP sachets.



13. Devitalisation

Devitalisation is:
- simple and easy to do
- does not affect flower quality
- can be combined with postharvest disinfestation dipping
- needs to be done by the industry as a whole to protect new varieties.

Devitalisation supports breeding of new varieties, giving industry maximum benefit from new varieties and maintaining marketing edge.

14. Disinfestation

Dipping is most effective for postharvest disinfestation of waxflowers.
Effective dipping relies on:
- good field control
- complete wetting of foliage/flowers
- immersion for 1 minute
- maintaining a clean dipping solution (free of dead insects)
- renewing insecticide and fungicide regularly.

Can be combined with devitalisation.
Dipping solution should contain insecticide, fungicide & wetter.

15. Cool chain

Cooled flowers maintain quality and extend vase life.
Maintain cool chain from harvest to end user by:
- harvesting in cooler parts of the day
- placing stems of harvested flowers in water, in the shade while in the field
- moving harvested flowers to processing shed as soon as possible
- processing flowers and getting them into the coolroom as soon as possible.

16. Storage and transport

Maintain the cool chain and keep:
- temperature between 0–2 °C
- relative humidity at 95–98 %

Ethylene management in transport and storage.
Refrigerated transport.
Track conditions during transport.