Postharvest Handling of Australian Flowers
- from Australian Native Plants and Related Species
A Practical Workbook

A report for the Rural Industries Research and Development Corporation

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Postharvest Handling of Australian Flowers

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Foreword

Correct postharvest treatment and handling is essential if flowers are to maintain quality during marketing and export. The aim of the project was to produce a book that would provide growers, wholesalers, exporters and retailers with practical information about postharvest handling and treatment of fresh wildflowers. Australian native flowers and related species, mainly South African Proteaceae, are included.

This publication provides advice on all aspects of postharvest handling, recommendations for more than 30 individual species and additional information on several aspects of postharvest treatment and marketing. It is intended to be a practical workbook, to help growers and all who handle these flowers to improve the quality of their flowers and the profitability of their business. The book was planned and written with advice from growers, exporters, R&D and extension workers and experts in workplace training.

This project (DAV-175A) was funded from RIRDC Core Funds, which are provided by the Federal Government.

This report, a new addition to RIRDC’s diverse range of over 700 research publications, forms part of our Wildflower & Native Plants R&D program, which aims to improve the profitability, productivity and sustainability of the Australian wildflower and native plant industry.

Most of our publications are available for viewing, downloading or purchasing online through our website:

downloads at www.rirdc.gov.au/reports/Index.htm
purchases at www.rirdc.gov.au/eshop

Peter Core
Managing Director
Rural Industries Research and Development Corporation
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The project was funded by RIRDC, Victoria’s Department of Natural Resources and Environment (DNRE) and three sponsors.

- Clearpac and Hortraco, suppliers of Chrysal products.
- Amcor Fibre Packaging.

Dennis Tricks (Longford Flowers) and Steve White (Tesselaar's) originally suggested the book.

Julia Kearton, Debbie Cosgrave and Margaret Fraser, of the Workplace Skills Access team at Swinburne University of Technology TAFE, Wantirna, Victoria, provided instructional design, desktop publishing and editing. Their excellent work made an invaluable contribution to the book.

In addition to the authors of this report, many people have made significant contributions.

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- Rod Jones, Jenny Beaumont, Gray Harrison and Peter Williams, Institute for Horticultural Development, DNRE, Knoxfield.
- Christine Horsman, President, Australian Flora & Protea Growers Association (AFPGA).
- Peter Brooks, FECA and Collina Export.
- William and Sarah Bliss, Wobolea Pty Ltd.
- Ken Young, Ebonybrook, Qld.
- Bettina Gollnow, NSW Agriculture.
- Jim Stranger, DNRE.
- Cynthia Carson, Queensland Department of Primary Industries.
- Andrew Macnish, School of Agriculture and Horticulture, University of Queensland, Gatton.
- David Mathews, Proteaflora, Vic.
- Kate Delaporte, University of Adelaide.
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- Gordon Dick, NSW.
- Geoff Sullivan, AUSBUDS.
- Kylie Treble, University of Melbourne.
- Brian Banovich, Daly Laboratories, Perth.

Other growers, exporters and R&D and extension workers also provided advice and information.

We thank David Evans and Cecile Ferguson of RIRDC and Denise Millar and Bruce Tomkins of DNRE for their support of this project.

The Faragher family, Jenny Dexter, Rose and Ella, graciously tolerated John working on this book on weekends and holidays.
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Executive summary

The aim of the project was to produce a book that would provide growers, wholesalers, exporters and retailers with practical information about postharvest handling and treatment of fresh wildflowers. Australian native flowers and related species, mainly South African Proteaceae, are included.

Few reference and practical books on postharvest handling of cut flowers are available. However, the information on Australian native flowers and related species is dispersed amongst research papers, student theses, reviews, RIRDC reports, industry articles, filing cabinets and importantly, in the minds of growers, wholesalers, exporters and retailers. Our aim was to bring together this information, along with other practical information that the grower, wholesaler and exporter need and present it in a user-friendly, practical workbook. The book was planned with advice from growers, exporters, research and development (R&D) and extension workers and experts in workplace training.

The major sections of the book are as follows.

1. Why are postharvest treatments important?
2. Basic postharvest treatments and handling for all cut flowers and foliage.
3. A general postharvest treatment method.
4. Specific postharvest treatments for individual crops.
5. Further information on postharvest treatments and handling.

Because we have reviewed the R&D literature and collected information from the practical experiences of growers and exporters to produce this book, we are able to summarise what is known about postharvest handling of Australian native flowers and their relatives.

There is adequate information available concerning:

- the postharvest behaviour and requirements of some flowers that have been researched and worked with intensively, eg Chamelaucium uncinatum (Geraldton waxflower) and to a lesser extent Anigozanthos (kangaroo paw), Grevillea, Leucadendron, Leucospermum, Ozothamnus (rice flower), Protea, Telopea (waratah) and Thryptomene (Grampians thryptomene)
- the vase life and behaviour in the vase of many freshly picked flowers
- the ability to cold store or ship flowers for prolonged periods.

There is inadequate information available concerning:

- practical postharvest treatments for export, to ensure that flowers survive export well
- the detailed postharvest biology of many flowers, including ethylene sensitivity, abscission (flower and petal drop) and the importance of Botrytis (grey mould) and other fungi
- practical treatments for many flowers, e.g. Banksia, Crowea, Eriostemon, Eucalyptus, Leptospermum (tea tree), Serruria and others
- the way in which many flowers respond to ethylene and anti-ethylene treatments, including the new, environmentally friendly 1-MCP
- varietal differences in postharvest life, e.g. in Chamelaucium
- simple, quick and inexpensive treatments that growers, wholesalers and exporters require
• the practical issues and consequences surrounding registration and regulation of using agricultural chemicals.

Future R&D and extension work needs to discover and make available some of this information.

There is still a need for R&D and extension workers to work more closely with growers, exporters, wholesalers, importers and retailers to devise and implement good, practical postharvest treatments.

The book should be added to by the users and updated in three years time. It can be used as an extension and training tool. For example, four successful workshops on postharvest handling, based on the book, were held with growers in Victoria during 2001. It can also be used to develop quality assurance practices and manuals and as a student text.
Abbreviations

Units:
°C  degrees Celsius
%  per cent
/  per
μl  microlitre (1,000,000 μl = 1l)
μmol  micromole
cm  centimetre
g  gram
g/l  gram per litre
kg  kilogram
l  litre
M  molar (1 mole per litre)
mol  mole
mmol  millimole (1000 mmol = 1 mol)
mm  millimetre (1000 mm = 1 m)
ml  millilitre (1000 ml = 1l)
ml/l  millilitre per litre
mM  millimolar (millimole per litre)
ppm  parts per million

Other abbreviations:
1-MCP  1-methylcyclopropene
2,4-D  2,4-dichloro phenoxyacetic acid
AFPGA  Australian Flora and Protea Growers Association
Ag⁺  silver (ion)
a.i.  active ingredient
AUF  Australian United Fresh Fruit and Vegetable Association Ltd.
AQIS  Australian Quarantine and Inspection Service
BCDMH  bromochloro-dimethylhydantoin
CALM  Department of Conservation and Land Management (WA)
DICA  dichloroisocyanurate (a stabilised pool chlorine)
DNRE  Department of Natural Resources and Environment, Victoria.
EA  Environment Australia
EPA  Environment Protection Authority
et al. and other authors

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FECA</td>
<td>Flower Export Council of Australia</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organisation for Standardisation</td>
</tr>
<tr>
<td>KI</td>
<td>potassium iodide</td>
</tr>
<tr>
<td>MB</td>
<td>methyl bromide</td>
</tr>
<tr>
<td>MCPA</td>
<td>(4-chloro-2-methylphenoxy)acetic acid</td>
</tr>
<tr>
<td>MSDS</td>
<td>Material Safety Data Sheet</td>
</tr>
<tr>
<td>NaCl</td>
<td>sodium chloride</td>
</tr>
<tr>
<td>NPWS</td>
<td>National Parks and Wildlife Service, NSW</td>
</tr>
<tr>
<td>NRA</td>
<td>National Registration Authority for Agricultural and Veterinary Chemicals</td>
</tr>
<tr>
<td>N.Z.</td>
<td>New Zealand</td>
</tr>
<tr>
<td>OHS</td>
<td>Occupational Health and Safety</td>
</tr>
<tr>
<td>PIRSA</td>
<td>Primary Industries and Resources, South Australia</td>
</tr>
<tr>
<td>QA</td>
<td>Quality Assurance</td>
</tr>
<tr>
<td>QDPI</td>
<td>Queensland Department of Primary Industries</td>
</tr>
<tr>
<td>QW&amp;NFA</td>
<td>Queensland Wax and Native Flower Association</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>research and development</td>
</tr>
<tr>
<td>RH</td>
<td>relative humidity (%)</td>
</tr>
<tr>
<td>RIRDC</td>
<td>Rural Industries R&amp;D Corporation</td>
</tr>
<tr>
<td>SARDI</td>
<td>South Australian Research &amp; Development Institute</td>
</tr>
<tr>
<td>SQF</td>
<td>Safe Quality Food (a quality assurance scheme)</td>
</tr>
<tr>
<td>STS</td>
<td>silver thiosulphate</td>
</tr>
</tbody>
</table>
**Plant and fungal names used**

We have used botanical names throughout this book. The first botanical name used is the genus, eg *Telopea*. This may be followed by the species name, eg *speciosissima*. Botanical names are written in italics. The botanical name is sometimes followed by the name of the hybrid or variety, eg ‘Shady Lady’. Following is a list of the botanical names used and the matching common names.

<table>
<thead>
<tr>
<th>Botanical name (genus)</th>
<th>Common name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia</td>
<td>Wattle</td>
</tr>
<tr>
<td>Actinotus</td>
<td>Flannel flower</td>
</tr>
<tr>
<td>Adenanthos</td>
<td>Woolly bush</td>
</tr>
<tr>
<td>Agathis</td>
<td>Kauri pine</td>
</tr>
<tr>
<td>Agonis</td>
<td>(West Australian) tea tree</td>
</tr>
<tr>
<td>Alloxylon</td>
<td>Dorrigo waratah</td>
</tr>
<tr>
<td>Anigozanthos</td>
<td>Kangaroo paw</td>
</tr>
<tr>
<td>Astartea</td>
<td></td>
</tr>
<tr>
<td>Athertonia</td>
<td></td>
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<tr>
<td>Backhousia</td>
<td></td>
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<tr>
<td>Baeckea</td>
<td></td>
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<tr>
<td>Banksia</td>
<td></td>
</tr>
<tr>
<td>Beaufortia</td>
<td>Swamp bottle brush</td>
</tr>
<tr>
<td>Blandfordia</td>
<td>(NSW) Christmas bells</td>
</tr>
<tr>
<td>Boronia</td>
<td></td>
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<tr>
<td><em>Bracteantha</em> (the new name for some <em>Helichrysum</em>)</td>
<td>Everlasting daisy</td>
</tr>
<tr>
<td>Callistemon</td>
<td>Bottle brush</td>
</tr>
<tr>
<td>Calomeria</td>
<td>Incense flower</td>
</tr>
<tr>
<td>Calothamnus</td>
<td>One-sided bottlebrush</td>
</tr>
<tr>
<td>Cassinia</td>
<td>Yellow rice flower</td>
</tr>
<tr>
<td>Caustis</td>
<td>Koala fern</td>
</tr>
<tr>
<td><em>Ceratopetalum</em></td>
<td>Christmas bush, festival bush</td>
</tr>
<tr>
<td>Chamelaucium</td>
<td>Geraldton waxflower, waxflower</td>
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<tr>
<td>Conospermum</td>
<td>Smoke bush</td>
</tr>
<tr>
<td>Corynanthera</td>
<td>Golden cascades</td>
</tr>
<tr>
<td>Crowea</td>
<td></td>
</tr>
<tr>
<td>Cryptandra</td>
<td>Cotton bush, corroboree bush</td>
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<tr>
<td><em>Darlingia</em></td>
<td>Brown silky oak</td>
</tr>
<tr>
<td>Darwinia</td>
<td>Mountain bells</td>
</tr>
<tr>
<td>Dasypogon</td>
<td>Saviour grass</td>
</tr>
<tr>
<td>Dicranopterus</td>
<td>Broad leaf umbrella fern</td>
</tr>
<tr>
<td>Botanical name (genus)</td>
<td>Common name</td>
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<tr>
<td>---------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
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<tr>
<td>Dodonaea</td>
<td>Hop bush</td>
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<tr>
<td>Doryanthes</td>
<td>Gymea lily</td>
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<tr>
<td>Dryandra</td>
<td>Dryandra, bush rose</td>
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<td>Eremophila</td>
<td>Emu bush</td>
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<tr>
<td>Erica</td>
<td>Erica, heath, heather</td>
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<tr>
<td>Eriostemon (some species that were</td>
<td>Eriostemon, waxflower</td>
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<td>named Eriostemon are now named</td>
<td></td>
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<tr>
<td>Philotheca</td>
<td></td>
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<tr>
<td>Eucalyptus</td>
<td>Eucalyptus, gum</td>
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<tr>
<td>Gahnia</td>
<td>Saw sedge</td>
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<tr>
<td>Geleznowia</td>
<td>Yellow bells</td>
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<td>Gleichenia</td>
<td></td>
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<td>Grevillea</td>
<td>Grevillea, Spiderman</td>
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<td>Guichenotia</td>
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<td>Hakea</td>
<td>Hakea, pink spikes</td>
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<td>Hypocalymma</td>
<td>Hypocalymma, myrtle</td>
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<td>Isopogon</td>
<td>Coneflower, drumsticks</td>
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<td>Ixodia</td>
<td>South Australian daisy, hills daisy</td>
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<td>Kunzea</td>
<td></td>
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<tr>
<td>Lachnostachys</td>
<td>Lambstail</td>
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<tr>
<td>Lepironia</td>
<td>Digeri sticks</td>
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<tr>
<td>Leptospermum</td>
<td>Tea tree</td>
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<tr>
<td>Leucadendron</td>
<td></td>
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<tr>
<td>Leucopogon</td>
<td>Tassel flower</td>
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<tr>
<td>Leucospermum</td>
<td>Pincushions</td>
</tr>
<tr>
<td>Lomatia</td>
<td>Crinkle bush</td>
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<td>Lophomyrtus</td>
<td>(N.Z.)</td>
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<tr>
<td>Lycopodium</td>
<td>Coral fern</td>
</tr>
<tr>
<td>Lysinema</td>
<td>Curry and rice</td>
</tr>
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<td>Macropidia</td>
<td>Black kangaroo paw</td>
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<tr>
<td>Macrozamia</td>
<td>Burrawang</td>
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<td>Melaleuca</td>
<td>Bottlebrush</td>
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<td>Metrosideros</td>
<td>Pohutukawa (N.Z.)</td>
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<tr>
<td>Micromyrtus</td>
<td>Fringed heath myrtle</td>
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<tr>
<td>Musgravea</td>
<td></td>
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<tr>
<td>Ozothamnus (the new name for some</td>
<td>Rice flower</td>
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<tr>
<td>Helichrysum)</td>
<td></td>
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<tr>
<td>Persoonia</td>
<td>Cherry bush, Barker bush, snotty gobble, Geebung</td>
</tr>
<tr>
<td>Botanical name (genus)</td>
<td>Common name</td>
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<tr>
<td>------------------------</td>
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</tr>
<tr>
<td>Petrophile</td>
<td>Conesticks</td>
</tr>
<tr>
<td>Philotheca (the new name for some Eriostemon)</td>
<td>Eriostemon, waxflower</td>
</tr>
<tr>
<td>Pimelea</td>
<td>Qualup bells (P. physodes)</td>
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<tr>
<td>Platysace</td>
<td>Valentine’s lace</td>
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<td>Placospermum</td>
<td>Rose silky oak</td>
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<tr>
<td>Podocarpus</td>
<td>Emu grass</td>
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<tr>
<td>Protea</td>
<td>Mulla mulla</td>
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<tr>
<td>Ptilotus</td>
<td>Billy buttons</td>
</tr>
<tr>
<td>Pycnosaurus</td>
<td>Everlasting daisy</td>
</tr>
<tr>
<td>Regelia</td>
<td>Blushing bride</td>
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<tr>
<td>Rhodanthe (previously Helipterum)</td>
<td>Fine leaf umbrella fern</td>
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<tr>
<td>Scholtzia</td>
<td>Sturt’s desert pea</td>
</tr>
<tr>
<td>Serruria</td>
<td>Waratah</td>
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<tr>
<td>Stenocarpus</td>
<td>Retusa</td>
</tr>
<tr>
<td>Sticherus</td>
<td>Grampians thryptomene (T. calycina)</td>
</tr>
<tr>
<td>Stirlingia</td>
<td>Feather flowers</td>
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<tr>
<td>Swainsona (S. formosa was previously Clianthus formosa)</td>
<td>Everlasting daisy</td>
</tr>
<tr>
<td>Telopea</td>
<td>Gras tree, steel grass</td>
</tr>
<tr>
<td>Templetonia</td>
<td></td>
</tr>
<tr>
<td>Thryptomene</td>
<td></td>
</tr>
<tr>
<td>Verticordia</td>
<td></td>
</tr>
<tr>
<td>Waitzia</td>
<td></td>
</tr>
<tr>
<td>Xanthorrhoea</td>
<td></td>
</tr>
<tr>
<td>Ziera</td>
<td></td>
</tr>
</tbody>
</table>

**Fungi**

<table>
<thead>
<tr>
<th>Botanical name (genus)</th>
<th>Common name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternaria</td>
<td>Alternaria rot</td>
</tr>
<tr>
<td>Botrytis</td>
<td>Grey mould</td>
</tr>
<tr>
<td>Elsinoe</td>
<td>Elsinoe scab</td>
</tr>
<tr>
<td>Elsinoe</td>
<td>A form of Alternaria and Stemphylium fungi</td>
</tr>
<tr>
<td>Puccinia</td>
<td>Puccinia rust</td>
</tr>
<tr>
<td>Stemphylium</td>
<td>Stemphylium rot</td>
</tr>
</tbody>
</table>
About this book

The book was designed to be a practical book, to be used in the packing shed and work place. It is in a loose-leaf folder so that the user can add to it and so that it can be updated. It is printed on heavy paper to survive regular use and the odd coffee spill. We have provided space for the user to write in extra notes.

We hope to update the book in future. If you wish to provide corrections or extra information, they will be included in a future edition.

Before reading and using the book, please note the following explanations.

- Where insecticides and fungicides are mentioned we have only mentioned those that are registered by the National Registration Authority for Agricultural and Veterinary Chemicals (NRA) for that use.
- For insecticides and fungicides, we have usually used only the chemical name of the active ingredient as there are so many products with the same active ingredient.
- To simplify information, some trade names of products have been used. No endorsement of named products is intended, nor is criticism implied of similar products that are not mentioned.
- A detailed glossary that explains technical terms is included as Section 8.
- For simplicity, the words “flowers” or “stems” have been used to mean the whole commercial cut flowering stem. This includes the stem, leaves, flowers or flower head. The word “flower” is also used to mean the individual flowers on a stem (eg Chamelaucium) or in a flower head (eg in Telopea). Where it may be unclear if the word “flower” means the whole, commercial flowering stem or the individual flower, the words “individual flower” are used. The words “flower head” are used to describe the many compound flowers such as Acacia (balls or rods), Banksia, Grevillea, Helichrysum, Ozothamnus, Protea and Telopea.
- The term “vase life” means the life of the flower from the time it is placed in a vase of water at approximately 20°C, 60% to 70% relative humidity (RH) and 12 hours to 24 hours of bright room lighting a day. Usually this is for freshly cut flowers, but sometimes it is after transport or cold storage, in which case we say so. Vase life is in the eye of the beholder and is affected by many things, so the vase lives quoted by different people for any particular species vary.
- Many sources of information were used in compiling this book. Not all the sources and references are quoted, but they are available from the authors on request.
1. Why are postharvest treatments important?

Cut flowers slowly deteriorate and lose quality after harvest. Good postharvest treatment slows the loss of quality.

- **Quick handling** gets the flowers to your customer while they still look fresh.
- **Clean water** for the stems and humid, cold air around the leaves and flowers helps stop wilting. Recutting the base of the stem and/or adding hydrating treatments to the water often improves water uptake.
- **Cold handling** dramatically delays quality loss, water loss and death. For example cooling *Chamelaucium uncinatum* from 10°C to 1°C reduces its rate of aging to one-quarter.
- **Postharvest solutions** can improve water uptake, delay aging and deterioration and improve flower opening.
- **Ethylene** protection for sensitive flowers will reduce flower drop and aging. Exposure to ethylene can be sometimes avoided and its action can be slowed or stopped by anti-ethylene treatments.
- **Pest control** kills insects that would otherwise lead to flowers being rejected in the market place, or fumigated at the growers'/exporters’ expense. Fungicide treatment may be needed to control fungal growth on some flowers.
- **Packaging** enables efficient transport, protects flowers physically and keeps cold flowers cool and humid.

![Photo](image1.jpg) Photo courtesy of AFPGA

Postharvest treatments bring **financial benefits** from better quality, less wastage and from satisfied customers.
2. Basic postharvest treatments and handling for all cut flowers and foliage

This section will outline the postharvest treatments that should be applied to all cut flowers and foliage, unless specific details are provided for individual crops in section 4.

The recommended treatments may not suit every flower or every business, so it is sensible to try out postharvest treatments before putting them into everyday use.

2.1 Flow charts for postharvest handling

On the following pages, there are a series of flow charts, which show some of the most common methods and processes for postharvest handling of cut flowers. Each chart has comments on where/when that particular method or process is most likely to be used, and its advantages and disadvantages. Only a few of the many possible flow charts are shown.

Each grower, exporter and wholesaler must work out which of the charts best fits their own situation. This will depend on getting the right balance between:

- applying the necessary treatments to flowers
- processing and transporting the flowers as quickly as possible
- efficient use of labor and space
- keeping costs down.

The first flow chart reminds us that it is a long, slow and sometimes very difficult path from grower to the final customer. The flowers pass through many hands and many different environments. There are many links in the handling chain and the final quality of the flowers depends on everyone looking after them.

“The overall chain is only as strong as the weakest link.” The weakest links in the cut flower industry are those where the flowers get too hot, where they dry out and where there are delays in moving the flowers on to the final customer.
Flow chart 1 shows the total flower handling chain, with all the links involved in getting the flower from harvest stage to the final customer.

**Flow Chart 1. From harvest, to final customer**

Flow Charts 2 – 9 show all the parts of the handling chain that the grower is responsible for – from harvest, to handing over flowers for transporting.

Flow Charts 2 & 3 show the two most common postharvest methods used.

**Flow Chart 2. Process, grade and bunch before cooling**

**Flow Chart 3. Cool and place in water before processing, grading, bunching**

Flow charts 4 – 7 show other methods used by growers in special cases.

**Flow Chart 4. Transport in buckets**

**Flow Chart 5. No cooling**

**Flow Chart 6. Dry handling – pack in the shed**

**Flow Chart 7. Dry handling – pack in the field**

Flow charts 8 & 9 show in detail, the different methods that growers can use to manage particular risk factors.

**Flow Chart 8. Options for pest and disease control**

**Flow Chart 9. Options for anti-ethylene treatments.**

**Reading the flow charts**

Most of the flow charts show two different sets of steps for that overall method.

- Follow the steps and arrows down the centre of the chart until you reach a step that has two arrows coming off it – one going to the left and one to the right.
- Read the first steps on the top of the left and right hand sides, then choose which one best suits your particular situation.
- Continue to follow the steps down the side you have chosen. In some cases the final step(s) will come together in the centre.
Flow chart 1. From harvest, to final customer

- Grower - harvest
  ↓
- Processing (grading and bunching)
  ↓
- Postharvest treatments
  ↓
- Packing
  ↓
- Exporter
  ↓
- Freight forwarder
  ↓
- Air transport
  ↓
- Importer/wholesaler
  ↓
- Wholesaler
- Retailer
  ↓
- Final customer
Flow chart 2. Process, grade and bunch before cooling – with and without forced-air cooling

Use this flow chart when:
- Processing can be done quickly.
- Cooling and water are not essential immediately after harvest.
- Forced-air cooling equipment is installed in the cold room.

Advantages:
- Can be quick and efficient

Disadvantages:
- Risk of quality loss if flowers are not cooled or given water quickly

Notes:
1. Water, postharvest solutions, pest and disease treatments and anti-ethylene treatments can be applied at this stage if necessary. Some treatments can be combined. Treatments can also be combined with cooling (passive cooling in a cold room). See flow charts 8 and 9 for pest and disease control and anti-ethylene treatment options.
Flow chart 3. Cool and place in water before processing, grading, bunching – with and without forced-air cooling

Use this flow chart when:
- Cooling and placing in water are essential immediately after harvest.
- Processing cannot be done quickly.
- Forced-air cooling equipment is installed in the cold room.

Advantages:
- Cooling, water, postharvest solutions can greatly improve the quality of flowers, particularly if they have been hot or water stressed in the field, or have not been transferred from the field to the packing shed quickly.

Disadvantages:
- Cooling, water and postharvest treatments are applied to flowers that may later be thrown out.

Notes:
1. Other treatments can be applied during the cooling and water treatments, e.g. postharvest solutions, pest and disease treatments and anti-ethylene treatments. See flow charts 8 and 9 for pest and disease control and anti-ethylene treatment options.
Flow chart 4.  Transport in buckets

Left hand side shows processing before cooling and postharvest treatments
Right hand side shows cooling and postharvest treatments before processing.

Use this flow chart when:
- Flowers are for the local market e.g. wholesalers, supermarkets, retailers.
- Flowers are for export and when the exporter or a wholesaler will package the flowers

Advantages:
- Saves the big costs of cartons and labor for packaging
- Flowers are in water (and flower food) during transport and immediately after transport.

Disadvantages:
- Buckets take up a lot of space in cold rooms and during transport.

Notes:
1. See flow charts 8 and 9 for pest and disease control and anti-ethylene treatment options.
Flow chart 5. No cooling

This is not a recommended method, because quality and vase life will be lost, but there are ways of keeping the losses small if it is necessary to handle flowers with no cooling.

Left hand side shows processing before water and postharvest treatments
Right hand side shows water and postharvest treatments before processing.

When to use this flow chart:
- When you can’t afford a cold room. Hold the flowers in water and transport the flowers quickly.

Disadvantages:
- Quality and vase life will be lost during the time without cooling.

Notes:
1. See flow charts 8 and 9 for pest and disease control and anti-ethylene treatment.
Flow chart 6. Dry handling – pack in the shed

Use this flow chart when:
- Large amounts of flowers need to be handled and they can be handled quickly (1 to 2 hours from cutting to forced-air cooling).
- Flowers are not damaged by some drying and don’t need any postharvest treatments.
- Forced-air cooling is available.

Advantages:
- Can (must) be quick
- Uses small amounts of labor and space
- Enables handling large amounts of flowers

Disadvantages:
- The flowers will dry out and be damaged, unless they are packaged and cooled quickly.
- There is no place for water, postharvest solutions or anti-ethylene solutions (STS).

Notes:
1. Insecticide fumigation and anti-ethylene fumigation (1-MCP) could be applied (separately), after forced-air cooling, using the forced-air system to circulate the fumigants. If this is done at warm temperatures the flowers will then need re-cooling.
2. Alternatively, pest and disease and anti-ethylene treatments could be made by an exporter/wholesaler. See flow charts 8 and 9 for pest and disease and anti-ethylene treatment options.
Flow chart 7. Dry handling – pack in the field

Use this flow chart when:
- Large amounts of flowers need to be handled and they can be handled quickly (1-2 hours from cutting to forced-air cooling).
- Flowers are not damaged by some drying and don’t need any postharvest treatments.
- Forced-air cooling is available.

Advantages:
- Reduces handling, and therefore cost

Disadvantages:
- The flowers will be damaged by drying out unless they are cooled quickly.
- There is no place for water, postharvest solutions, anti-ethylene solutions (STS), or pest control with dips.

Notes:
1. Insecticide fumigation and anti-ethylene fumigation (1-MCP) could be applied (separately) after forced air cooling, using the forced air system to circulate the fumigants. If this is done at warm temperatures the flowers will then need to be re-cooled.
2. Alternatively, pest and disease and anti-ethylene treatments could be made by an exporter/wholesaler. See flow charts 8 and 9 for pest and disease and anti-ethylene treatment options.
Notes:
1. Insecticide gases (fumigation) need to be applied at 15°C to 20°C, for 2 to 15 hours, depending on the gas.
Notes:
1. Short treatments before cooling, or long treatments during cooling. 1-MCP is not yet available in Australia.
2. Where forced air cooling is available 1-MCP can be circulated by the cooling system and can be applied for a short period at warm temperatures and then the flowers would be re-cooled, or applied for longer periods at cool temperatures.
2.2 Production factors affecting postharvest quality

It is important that flowers are grown in such a way that they have good postharvest quality and life.

- Grow species and varieties that have a long flower life and do not have problems with tip growth, flower drop, drying out, leaf blackening, infection such as *Botrytis cinerea* (grey mould), sticky flowers or high ethylene sensitivity. For example, different varieties of *Chamelaucium uncinatum* have vase lives varying from 5 to 13 days!
- Choose species that grow well in your conditions.
- Avoid picking flowers from weak, poorly growing plants as they often have short lives. This may also be true for some bush-picked flowers.
- Use good production practices, such as appropriate fertilising, irrigation and wind protection, to increase vase life (e.g. *Chamelaucium uncinatum*). Flowers of *Chamelaucium* from cultivated plants were found to have vase lives up to double those of bush picked flowers. *Ceratopetalum* needs shelter from hot dry winds or else vase life and quality are reduced.
- Prevent soft tip growth by reduced irrigation and fertilising, other growth slowing treatments and picking before the soft growth occurs.
- Avoid serious water stress before harvest. In some flowers, it causes flower and leaf drop and wilting (e.g. *Ozothamnus*). Watering the night before picking can overcome this problem.
- Watch for flowers that are likely to be infected by *Botrytis* (e.g. *Chamelaucium*). They may need to be sprayed with a registered fungicide during production.
- Reduce insects and snails on flowers in the field. This can be done by removing weeds that harbor pests and spraying with registered insecticides.
Climate may also affect vase life. Many of the tropical grevilleas have a longer vase life when they are picked in the northern Australian autumn-winter than in spring-summer. Some grevilleas have short lives when grown in cool climates, so they may not be suitable for southern Australia.

Blackening of *Protea* leaves, in some species, is worse in autumn-winter than summer, in southern Australia. Leaf blackening is also affected by many other conditions: drought, water logging, stressed plants and possibly by low manganese, zinc and nitrogen nutrition, and the plants being too old.

2.3 Harvesting

Harvest stage

The stage of harvest depends on the species and the market. Markets vary a lot in what they want. It is best to ask your buyer what they want. Often harvest is when individual flowers are starting to open, or when about 25% of individual flowers on a stem or flower head are open. However, consider the following points also.

- If flowers are picked too early they may not open.
- If flowers are picked when they are too mature they will have too short a life. Some flowers are picked when they first start to open because they open a lot during export e.g. *Protea repens*.
- Some species are very susceptible to flower drop if they are picked when fully open, or late in the season, so this should be avoided e.g. *Thryptomene calycina* and *Baeckea behrii*.

How often you pick depends on the species, market and weather. At one extreme, summer *Protea repens* need to picked twice a day!

The suggested harvest stages for *Protea*, *Leucadendron* and *Leucospermum* species are described in the AFPGA booklet, (AFPGA 2000). The harvest stages for rice flower are shown in Beal, Carson, Turnbull and Forsberg (2001).

You can make drawings or get pictures of your harvest stages so you and your staff know what they are.
Harvesting

Where possible avoid picking at the end of a hot day or during the hottest part of the day in summer e.g. when it is over 30°C.

It is also best not to pick some flowers when they are wet e.g. proteas that are at risk of leaf blackening. If flowers have to be picked wet, make sure they are dry before packing.

There are many methods of harvesting, but the 2 main ones are based on how the flowers mature on the plant.

1. Select stems carefully for their maturity and quality. This method suits plants whose flowers mature at different times.

2. Cut all stems on the plant and grade them later in the packing shed. This method suits flowers that mature together and helps with rapid harvesting, but care needs to be taken that the plants aren’t damaged.

Flowers should always be cut with sharp secateurs or hedge cutters.

- Use secateurs, or cutters, that match the size of the stems.
- Keep secateurs clean and sharp.
- Consider using secateurs with revolving handles, or powered secateurs, if you need to cut a lot of stems.
- Make a straight or angled cut. It doesn’t matter which.
- Dip secateurs in disinfectant between bushes if diseases that can be spread from plant to plant are present (e.g. *Elsinoe* scab in proteas).
Pick in way that leaves the plants in a strong position to develop the next crop of flowers. Avoid over-picking and damaging the plants.

Flowers can be placed in water in the field, or handled dry until they reach the packing shed. Remember the following points.

- Holding flowers in water is worth the effort if they are sensitive to drying out and it is hot and dry.
- If water is used in the field it should contain a germicide, hydrating solution or commercial postharvest solution and the buckets should be clean.
- If flowers are handled dry they should be transported to the packing shed as soon as possible. It is not good to leave flowers out of water for more than 15 to 30 minutes.
- While the flowers are in the field, it is worth placing them in the shade, either natural shade or on a covered trailer.
- The buckets of flowers need to be small enough that they can be carried by hand and there needs to be an efficient method to transport them back to the packing shed e.g. on a truck or trailer.
An alternative is to harvest, grade, bunch and pack in the field and then take the flowers to the cold room for forced-air cooling. This may be a good way to reduce handling and labour costs. It is essential to get the flowers from the field to the forced-air cooler quickly. This method is suitable for flowers that need no postharvest water or solutions and no postharvest fumigation.

Don’t pick more flowers than you can process that day! Generally, one picker keeps one packer working, unless the pickers also bunch the flowers, in which case two pickers keep one packer working.

**Harvest labour is a major cost**

Every time a stem is handled, an extra cost equal to the cost of growing the flowers is added. Here are some possible ways to reduce costs.

- Only pick when you are confident you can sell the flowers.
- Give pickers clear instructions about what is to be picked and how it’s to be picked, and what the harvest stage and quality standards are.
- Use powered secateurs.
- Have experienced pickers grade and bunch as they pick.
- Don’t take flowers into the packing shed if you know they are not good enough for sale.
- Make it easy for pickers to put flowers into buckets or trays and on trailers. For example, avoid bending and heavy lifting by placing buckets on a raised platform or trailer, and place buckets at the end of each row.
- Provide an efficient way for the flowers to be collected from the field and taken to the packing shed.

**Transport**

Transport in the field varies from a tractor and trailer, or small 4WD vehicles with trailers, to hand-pulled carts and carrying flowers by hand. Buckets, containers or trays need to sit securely on trolley/trailer.

**Records**

Keep records of the number and type of flowers harvested, what block they are from and any observations on pests, diseases and quality. These records can later be linked to records of what is packed, what is sold and the price received.

See Work Sheet 1, Section 6.
2.4 Cooling

Cooling reduces aging and water loss in flowers. At 2°C to 4°C, aging and water loss are less than one-fifth of what they are at 20°C.

When to cool

Flowers should be cooled soon after harvest (e.g. within 1 hour) to remove field heat. They should also be cooled before transporting, to keep their quality during the journey to the next person in the handling chain. Sometimes handling can be managed so there is only one cooling period – see the flow charts in Section 2.1.

The best temperature

Most flowers are best cooled to 2°C to 4°C as long as there is no risk of freezing. Some flowers, particularly those from tropical regions, are damaged by cold temperatures above 0°C (chilling injury). Some examples are anthuriums, heliconias, gingers and flowers and foliage from the Atherton Tablelands. These need to be held at 10°C to 15°C. Ceratopetalum is best held at 6°C to 8°C, not 2°C to 4°C. Some red colored Anigozanthos hybrids go dull when they are stored close to 0°C for a few days.

Chilling injury often only shows up after flowers have been moved to warmer temperatures. It makes leaves and petals turn clear, then brown, then dead. If you suspect that flowers are injured after holding them at 2°C to 4°C, hold them at a higher temperature and see if the same injury occurs.

The temperature in the cold room should be measured with an accurate thermometer, which is sitting in a glass of water. The water gives a measure of the cold room temperature without being affected by short-term changes such as doors opening or fans coming on. It is wise to measure and record the temperature every day. If a dial outside the cold room displays the temperature, it should be checked against an accurate thermometer at least once a week. For details of how to check the accuracy, i.e. calibrate a thermometer, see Section 5.3.
Cooling

There are two methods of cooling: passive cooling and forced-air cooling. When the simple term ‘cooling’ is used, it usually means passive cooling.

Passive cooling is simply placing the flowers in a cold room and allowing the cold air from the refrigeration unit to pass around the flowers. This can be very quick if the flowers are not packed tightly together, but takes a few hours for flowers in buckets. If flowers are in closed boxes, cooling is very slow – it can take 24 hours for warm (20°C) flowers to cool down to 2°C to 4°C.

Forced-air cooling is where cold air is forced through boxes of flowers. It is a quick, efficient and economic means of cooling, and it is easy to set up the equipment in existing cool rooms (see Section 5.2).
**Humidity**

It is important that the humidity in cold rooms is not less than 80% relative humidity (RH). Otherwise, the flowers can dry out. This is very likely to happen if the air movement in the room is high. Cold rooms can be designed for high humidity. However, many standard cold rooms run at less than 80% RH. Special, high humidity cold rooms, where the cold air passes through a shower of water, are available.

One way to keep the humidity around flowers, is to pack the flowers tightly together and cover them with sheets of plastic. Another way is to pack them in cartons or plastic sleeves. Flowers must be cooled before they are packed.

Humidity can be raised by dripping water onto a towel in front of fans or by throwing water on the floor. However, care needs to be taken with wet floors to avoid slipping, and the floors need to be cleaned regularly.

**Cold rooms**

Cold room designing for horticultural products is a special skill, so it is worth getting advice and buying your cold room from an expert with horticultural experience.

Plastic curtains at the entrance to the cold room keep heat out when doors are open. Consider having doors that close automatically.

Lights are important in cold rooms. They should be installed for safety. There is also evidence that lights reduce leaf blackening in proteas. Normal fluorescent room lights will do the job, but brighter lights do slow down blackening more.

**Ethylene**

Don’t cold store ethylene sensitive flowers (see list in Section 5.3) with fruit that produces ethylene e.g. apples, pears, melons, stone fruit, tomatoes and bananas.

**Changing temperatures**

If cold flowers are placed in warm air, water will gather on the flowers, which may cause protea leaf blackening and *Botrytis* growth. This is why it is important to avoid temperature changes around sensitive flowers.

**Insulation**

Once flowers are cold, they can be insulated against warming up. Some cartons are insulated, but they cost a lot. Polystyrene boxes are very well insulated, but they need ice or gel packs inside them to keep the flowers from heating up. Many markets don’t want polystyrene boxes.
A layer of insulating material can be placed over or under groups of cartons. For example, a sheet of polystyrene (50mm) underneath a stack of cartons can dramatically reduce heat entering the cartons from hot roads, tarmacs and trucks. A layer of builders' foil, or an insulating blanket, over the top of a pallet load of cartons, or inside an air freight container can keep heat out.

![Insulation, such as polystyrene, between pallet and flowers reduces heating.](image)

**Ice packs and gel-ice packs**

Placing ice packs or gel-ice packs in packages to keep the flowers cold only works if the packages are very well insulated from warm air outside the packages. If regular cartons are held at 20°C, the small amounts of ice pack that are usually placed in cartons (e.g. 500g to 1kg) melt and stop working in less than 24 hours. Ice packs do give the buyer the impression that you have looked after the flowers. Remember, ice packs should be wrapped in newspaper to avoid freezing the flowers and then placed on the top of the flowers.

![Gel-ice packs can help keep flowers cool.](image)

**Can you do without cooling?**

Not really, because quality and vase life is being lost all the time the flowers are above 2°C to 4°C. To keep loss of quality to a minimum and to extend vase life, any time without proper cooling should be short and flowers should be kept as cool as possible.

If individual growers cannot afford a good cold room, some form of cooperative cold rooms, or cooling at a nearby wholesaler or exporter, may be possible.
The “cool chain”

Flowers need to be kept cool during all stages of the handling chain. The links in the chain where cooling is most likely to be a problem are: farms without cold rooms; unrefrigerated transport; air terminals in both exporting and importing countries; and some retail florists. When your flowers leave you, you need to feel sure that the next person handling them will keep them cool!

Records: See Work Sheet 8, Section 6 for an example of how to record cold room temperature and humidity.

2.5 Water uptake and loss

Most, if not all flowers benefit from their stems being placed in water. It is recommended that flowers are kept in water for 4 to 12 hours after harvest. This should be in a cold room if possible. It is really important to minimise water stress on flowers. Water stress happens when water loss through the leaves is greater than water uptake through the stem.

Clean water

There are several things that assist in keeping the water clean.

- Stems should be clean and leaves that will be under water should be removed.
- Buckets should be plastic, as metal may react with postharvest solutions.
- Buckets should be cleaned after each use with detergent or bleach.
- Water should be rain or mains water. Bore and dam water should be avoided if it contains particles that would block stems. Particles can be allowed to settle out in a tank, be filtered out, or made to settle to the bottom using alum, a water treatment available in pool shops.
- Water should contain a germicide, hydrating solution or a commercial postharvest solution (See 2.7).
Water pH

Hard water contains minerals that make the water alkaline. Flower stems don’t take up alkaline water as well as they take up softer water. One way to make water more acidic, is to add citric acid at 0.2g/l.

Recutting stems

To make sure of good water uptake, stems that have been dry for more than an hour, or have been in water for some days, should be recut, by at least 2cm and quickly placed in water. There are sometimes advantages in recutting stems under water, but this is often not practical.

The Society for American Florists manual says that 40% to 60% of the possible life of a flower can be lost if the stem is not recut after being dry or in dirty water too long (Staby 1994).

It does not matter if the stems are cut straight or at an angle. It is best to not bash, split or burn stems – this damages stems and provides food for bacteria. Re-cutting stems improves flower opening and vase life.

The effect of re-cutting stems of Leptospermum rotundifolium ‘Lavender Queen’ after dry transport.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Flower opening (%)</th>
<th>Vase life (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not re-cut</td>
<td>40</td>
<td>7</td>
</tr>
<tr>
<td>Re-cut 50mm in air</td>
<td>50</td>
<td>8</td>
</tr>
<tr>
<td>Re-cut 50mm under water</td>
<td>60</td>
<td>9</td>
</tr>
</tbody>
</table>

Water pH can be measured with test strips from pool shops.
Hydrating solutions

If flowers are dry, or prone to drying out, it is worth putting them into a hydrating solution to improve water uptake (see 2.7). Warm water (40°C) and ice-cold water (0°C) can also improve water uptake. Deep water, even 15 to 20cm, improves water uptake by some flowers (e.g. *Leptospermum*, *Telopea*).

![Deep water (20cm, right) prevented tip wilting in *Leptospermum morrisonii*](image1)

Other treatments

While flowers are in water they can also be treated with anti-ethylene (see 2.6) and pest control treatments (see 2.9) if they are necessary.

Humidity and water loss from flowers

Water is lost from flowers into the air around them. The rate of water loss depends on the combination of humidity, the temperature of the air and the temperature of the flowers.

- Water loss is greatest when the relative humidity of the air is low.
- Water loss is least when the flowers and air are kept at low temperature.
- The rate of water loss is also higher when the temperature of the flowers is greater than the temperature of the air around them. For this reason, flowers lose water while they are cooling. However, once they are cold they don’t lose as much, so rapid cooling is important to reduce water loss.

![High humidity (95%, right) prevented wilting of *Grevillea* flowers](image2)
The relative humidity around flowers can be raised by:

- having a special high-humidity cold room
- throwing water on the floor of the cold room or packing shed
- packing flowers close together
- covering the flowers e.g. with a sleeve, plastic bag or sheet.

High rates of air movement also increase water loss from flowers. A balance needs to be achieved between having air movement high enough to cool the flowers and keep them cool, but not so high that it removes too much water from the flowers.

**Wetting the foliage**

Some growers claim that with some flowers, it is better to wet the foliage than hold the stems in water, because these flowers take up so little water through their stems compared to the amount they lose through their leaves, e.g. *Thryptomene calycina* and *Boronia megastigma*. However, if the stems are recut and placed in a hydrating solution they would take up enough water. Also, if flowers are infected with *Botrytis* fungus (e.g. *Chamelaucium uncinatum*, *Leptospermum* and probably *Thryptomene calycina*), spraying water on the flowers is likely to increase the fungus growth and cause flower drop.

**Tubes or sachets of water**

Stems can be placed in tubes or sachets of water (or flower food), or in floral foam, to supply water during transport. Large stems of orchids are sometimes transported in tubes. A grower, wholesaler or exporter needs to weigh up the benefits versus the costs of using such techniques.

**Holding without water**

If flowers are to go without water, it should only be for a short time, when the temperature is low (2°C to 4°C) and the humidity around the flowers is high (90% to 100%). With all of these conditions, loss of quality will be minimised.
2.6 Ethylene and anti-ethylene treatments

Ethylene

Ethylene is a gas and a natural plant hormone. It comes from both plant and non-plant sources such as:

- flowers infected with *Botrytis* fungus (grey mould) e.g. on *Chamelaucium*
- some aging flowers (e.g. carnations, *Telopea, Leptospermum, Chamelaucium*)
- ripe fruit, including fruit vegetables, e.g. apples, avocados, bananas, pears, kiwi fruit, mango, melons, paw-paw, stone fruit, tomatoes
- diseased, rotting and burning plant material
- cars, gas fork-lifts, aeroplanes, floor cleaner engine exhausts, gas heater exhausts and cigarette smoke
- brick and plastic factories
- banana ripening rooms.

Ethylene damage

Some flowers are damaged by ethylene. For example, ethylene causes individual flowers to drop in *Baeckea virgata, Chamelaucium uncinatum*, some *Grevillea*, and *Leptospermum* species and *Verticordia nitens*. It causes individual flowers to wilt and drop in *Boronia heterophylla*.

Sensitive flowers are damaged by exposure to as little as 0.01 parts per million (ppm) for more than a day and by 1ppm for 12 to 24 hours. These levels of ethylene have been measured in flower packing sheds, supermarkets, wholesale markets, distribution centres, trucks, fruit cold stores and roadside stalls and displays.

![Flower drop from Chamelaucium, caused by ethylene from Botrytis infected flowers.](image)

If flowers are producing ethylene, or are likely to come into contact with it, then it is important to apply anti-ethylene treatments to the flowers soon after harvest.

A list of flowers known to be sensitive or insensitive to ethylene is given in Section 5.3. Ethylene sensitivity can vary between varieties of a species. When it is not known if a particular flower is sensitive or not, there are simple methods to check their sensitivity (see Section 5.3).
When is anti-ethylene treatment necessary?

According to the United States Department of Agriculture, “the negative effects of ethylene are responsible for 30% of floriculture crop losses”.

It is worth using anti-ethylene treatment in the following situations.

- Sensitive flowers are producing a lot of ethylene, usually because the individual flowers are infected with *Botrytis*. In this case, it is extremely valuable to apply anti-ethylene treatments. This applies to *Chamelaucium* and possibly to *Leptospermum, Thryptomene calycina, Eriostemon, Baeckea* and other flowers that drop profusely.
- Flowers produce ethylene as they age. For example, consider applying anti-ethylene treatments to *Leptospermum, Ozothamnus* and *Telopea*.
- There is a significant chance of a high value flower coming in contact with ethylene. For example, a very sensitive, high value flower such as *Grevillea* is probably worth protecting and a moderately sensitive, low value flower such as *Thryptomene calycina* may not be.

Types of anti-ethylene treatments

For sensitive flowers, anti-ethylene should be the first and most important postharvest treatment.

If the sensitive flowers are producing ethylene themselves, then doing these things is worthwhile.

- Using a chemical blocker against ethylene action, such as silver thiosulphate (STS), or 1-methylcyclopropene (1-MCP, sold as EthylBloc®).
- Keeping the flowers cold, to reduce ethylene production and action.

If sensitive flowers are not producing their own ethylene, but might come in contact with it, then doing these things is worthwhile.

- Protecting flowers from contact with ethylene (e.g., don’t store or transport flowers with ripe fruit, don’t have dead plant materials in the packing shed or store room, ventilate the area where flowers are, remove ethylene from storage atmospheres with ethylene absorbents/scrubbers) (see Section 5.6).
- Treating flowers with products that block ethylene action – STS-based products or 1-MCP.
- Keeping the flowers cold, to reduce ethylene production and action.
Silver thiosulphate (STS)

Silver thiosulphate (STS) is supplied to the flower as a solution that moves up the stem. The silver blocks ethylene action in the flower.

STS treatment protects the following sensitive flowers from damage by ethylene in the air around the flowers: *Baeckea virgata*, *Boronia heterophylla*, *Chamelaucium uncinatum*, *Grevillea*, some *Leptospermum* species and *Verticordia nitens*.

STS treatment increases the life of some flowers such as *Grevillea 'Majestic'* , *Boronia heterophylla*, *Boronia 'Lipstick'* , *Crowea exalata*, *Lophomyrtus ralphii 'Krinkly'* (foliage), *Ozothamnus*, *Swainsona formosa* and sometimes *Chamelaucium uncinatum*.

STS can be bought as a ready-made STS solution and as commercial anti-ethylene products. The known suppliers of STS solutions and STS-based commercial products in Australia are listed in Section 5.18.

STS solutions can be made up and a recipe is given in Section 5.4. However, there are many disadvantages to making it up yourself, such as getting and weighing the ingredients, risk of errors, and occupational health and safety issues such as handling the poisonous silver ingredients. For these reasons it is often better to buy ready-made solutions or products.

STS is usually used at one of the following combinations of concentrations, treatment time and temperature. Note that mM is a chemical concentration that describes the amount of silver present (see Explanation of Terms):

- 4mM STS for 15 to 60 minutes at 20°C (depending on how quickly the solution is taken up).
- 0.5mM STS for 8 hours at 2°C to 4°C
- 0.2mM STS for 16 hours at 2°C to 4°C

Because of the risk of silver damaging the environment, STS may become unavailable in future.

Ethylene causes flower drop but STS prevents the ethylene effect.
Using STS

STS should be applied before, and often instead of, other postharvest solutions.

Follow these important steps in using STS.

- Store concentrated STS products in glass or plastic containers, in a dark place. They have a limited life (sometimes less than 3 months). Use them as soon as possible after mixing or buying them. A test to tell if STS solutions are still working is described in Section 5.4.
- Handle STS with care, as you would an insecticide. Avoid any direct contact with it and use protective clothing including gloves, eye-protection and skin protecting barrier cream. Wash hands, face and contaminated clothes after use. See the product label for safety precautions.
- Use only clean water, e.g. rain or mains water, when making up STS solutions.
- Keep STS solutions out of direct sunlight.
- Clearly write “STS” labels on buckets/tanks and use them only for STS.
- Rinse stems to remove dirt and then recut, to give best chance of uptake of the STS solution.
- Apply STS as a pulse to the stems. A pulse is a short term treatment with a postharvest solution. The concentration used and the time of treatment depend on many factors: temperature, relative humidity, air movement, and the size of the stems. Follow the recommendations on the label of commercial products. See Section 5.4 for more information.
- Apply STS in buckets/tanks, or to bunches moving along a conveyor belt with their stems in the solution.
- Keep solution free of rubbish, dirt, plant material – scoop, strain or filter it out.

It is best to use small amounts of STS solution, use it once, and then dispose of it. Suppliers of commercial STS solutions recommend re-using STS “at least once” and “for up to 5 days”. To check that the STS is working, use the test described in Section 5.4.

If using home-made solutions of STS, use one of these treatments:

<table>
<thead>
<tr>
<th>Concentration</th>
<th>Temperature</th>
<th>Time</th>
<th>Follow-up treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>4mM</td>
<td>20°C</td>
<td>15 to 60 minutes</td>
<td>Place flowers in water or a postharvest solution (not chlorine germicide) for at least an hour to carry the STS up to the flowers. They can then be cooled, packed and transported.</td>
</tr>
<tr>
<td>0.2mM</td>
<td>2°C to 4°C</td>
<td>16 hours</td>
<td>After this treatment, flowers would usually be packed and transported</td>
</tr>
<tr>
<td>0.5mM</td>
<td>2°C to 4°C</td>
<td>8 hours</td>
<td></td>
</tr>
</tbody>
</table>
See Work Sheet 3, Section 6 for a way of recording STS treatments.

**Difficulties with STS**

Sometimes STS treatment doesn't protect flowers. This is either because the STS had stopped working or the flowers did not get enough STS. There are several ways to avoid these difficulties.

- Test STS solutions to make sure they are still working. See Section 5.4 for the test recipe.
- Where possible, use long treatment times rather than short, as this increases the chance of getting the right amount of STS into the flowers e.g. use over night treatments in a cold room.
- Where possible use the same treatment conditions each time (concentration, time, temperature, humidity and air movement).
- Recognise that if the temperature is low, the humidity high, or the flowers are packed tightly together, STS uptake will be less than usual so you need to use a longer treatment time or a higher concentration.
- The amount of STS that needs to be taken up to protect *Chamelaucium* from ethylene has been calculated (see Section 5.4) If we assume that other flowers need approximately the same amount of STS we can measure the uptake during treatment and stop the treatment when enough STS has been taken up. See Work Sheet 4, Section 6.
- Test whether the flowers are protected by exposing them to ethylene (see Section 5.4).

Note that the signs of an overdose of STS are usually discoloration of flowers (e.g. mauve flowers turn dark purple), flower drop in *Chamelaucium* and blackening of leaves.

See Work Sheet 3, Section 6, for a way of recording STS treatments.

STS uptake can be measured by placing a bunch of flowers in a measuring cylinder. Here there was 440ml of solution in the cylinder before treatments (left) and 400ml after (right).
Disposal of STS

Follow directions on the label for the disposal of commercial STS products. Incorrect disposal can lead to poisoned soil, water, animals and humans. STS solution waste and any plant and soil debris needs to be collected for disposal by a silver reclaiming company. See ‘Waste reduction and disposal services’ in the Yellow Pages.

The silver in STS can be taken out of the solution by the following method.

- STS solution is poured into a drum (e.g. 20 litres or 200 litres) full of steel wool. (Commercial quantities of steel wool can be purchased).
- After a few hours the silver binds to the steel wool and settles to the bottom of the drum and can be removed.
- The remaining liquid, which should be free of silver, can be run off from a tap in the top half of the drum. It can be run into a second tank of steel wool to make sure it's free of silver or it can be disposed of.
- Check with the local sewage authority to see if the liquid can be put in the sewer.
- Check with the local council or EPA to see if the liquid can be disposed onto land, as long as it doesn't pollute surface or ground water.
• The steel wool needs to be replaced regularly. A 20l drum full of steel wool has the capacity to absorb up to 1000l of 4mM STS but it would be wise to replace the steel wool after 500l or less of STS.
• The silver and steel wool sludge in the bottom of the drum can be shovelled out. Alternatively a wide outlet can be inserted in the base of the drum and the silver sludge emptied through that. Wear protective clothing when handling silver waste.
• The silver sludge needs to be put into a container and sent to a silver reclamer or waste disposal company. It must not be disposed into sewer, land or water.

STS disposal: Silver can be separated from STS solutions by adding steel wool as described above, or by adding special salts that are provided with some commercial STS solutions such as Chrysal AVB (From the Pokon & Chrysal instruction sheet).

1-MCP, an alternative to STS

1-methylcyclopropene (1-MCP) is a new, highly effective fumigant that has been specially designed to block ethylene action. It is being sold in the USA as EthylBloc® by Rohm & Haas and by Floralife. 1-MCP will probably be readily available in Australia soon (see Section 5.18 for where to inquire). It is easy to use and safer than STS.

1-MCP extends the life of some ethylene sensitive flowers that produce their own ethylene, particularly during export, e.g. some Chamelaucium.

1-MCP also protects sensitive flowers from damage by external ethylene, e.g.: Alloxylon pinnatum, Boronia heterophylla, Chamelaucium uncinatum, Grevillea, Leptospermum, Telopea, Thryptomene saxicola and Verticordia nitens.

1-MCP prevents ethylene damage to Chamelaucium (left) and Grevillea (right).
Using 1-MCP

The following points are worth knowing about using 1-MCP.

- It can be used at any stage in the handling chain, but the earlier the better.
- It is a gas so apply it in a reasonably air-tight room, or tent.
- It can be applied either while flower stems are in water, or postharvest solutions, in a cold room, or while flowers are in cartons (as long as lids or vents are open and the air in the room is circulated e.g. by forced-air cooling).
- The label provides detailed instructions for preparation, use, safety precautions and disposal.
- It is used at very low concentrations, of 1ppm (1 μl/l) or less and can be used in various combinations of concentration, time and temperature. The current EthylBloc® label recommends that one concentration is used for 4 to 8 hours at 10°C to 25°C (longer time for lower temperatures) and a lower concentration for more than 10 hours at 10°C to 25°C.
- It is worth testing if treated flowers have been successfully protected, by exposing them to ethylene (see Section 5.3).

Difficulties with 1-MCP

A problem with 1-MCP is that its protection wears off with time. The amount of time can vary from 2 to 15 days in different flowers. There are reports of low doses of 1-MCP only protecting *Chamelaucium uncinatum* (Geraldton waxflower) for 4 days and *Grevillea* ‘Sylvia’ for 2 days.

This problem may be solved by higher doses of 1-MCP, repeated treatments, or slow release treatments (e.g. during transport). However it is clear that a single treatment with 1-MCP protects flowers for the brief, but critical period of export.

More information about EthylBloc is available from the web site: [www.ethylbloc.com](http://www.ethylbloc.com)

### 2.7 Postharvest solutions

There is a range of postharvest solutions that improve the vase life of cut flowers.

**Anti-ethylene treatments**, if they are necessary, should be the first and sometimes the only postharvest solution used (see details in Section 2.6).

**Germicides** are needed to stop bacteria (and algae, yeasts and fungi) growing – otherwise the bacteria block the flower stem and prevent water uptake. Therefore, flower water should always contain a germicide or a commercial postharvest solution that contains a germicide.

**Hydrating solutions** help the flower to take up water and may be particularly useful after flowers have been held or transported dry for some time.

**Sugar solutions** can improve opening, quality and vase life of some flowers. Sugar solutions must always include a germicide.
Commercial postharvest solutions usually contain a germicide, something to improve water uptake, sugar and possibly other helpful compounds. They provide a simple, convenient, accurate and often economical treatment for flowers at all stages of the handling chain.

All water used for cut flowers should contain at least a germicide or a proven commercial postharvest solution.

Germicides

These are the main types of germicides.

- Chlorine and bromine compounds, e.g. swimming pool chlorine.
- Quaternary ammonium compounds e.g. some nappy wash, hand wash, fruit and vegetable washes, nursery disinfectants, swimming pool algaecides and hospital disinfectants.
- Hydroxyquinoline citrate or hydroxyquinoline sulphate.
- Some commercial postharvest germicides.

Each of these germicides has advantages, disadvantages and safety issues. These are explained in Section 5.5.
**Chlorine germicides**

The simplest, safest and most effective germicides are probably the chlorine/bromine compounds. They have been tested with many wildflowers and have shown good effects on water uptake and vase life. The most commonly available chlorine germicides are:

<table>
<thead>
<tr>
<th>Type of chlorine germicide</th>
<th>Active ingredient</th>
<th>Strength / concentration of solution</th>
<th>Correct pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stabilised pool chlorine</td>
<td>DICA, sodium dichloroisocyanurate</td>
<td>30 to 60 parts per million (ppm) available chlorine (approx. 0.1g/l)</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Usually does not need adjusting.</td>
</tr>
<tr>
<td>Other pool chlorine powders</td>
<td>Calcium hypochlorite</td>
<td>50 to 60 ppm available chlorine (approx. 0.1g/l)</td>
<td>Needs adjusting down to 6 – 8.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Add citric acid or hydrochloric acid (available from pool shops) at approx 0.005g/l, to make sure the chlorine works.</td>
</tr>
<tr>
<td>Liquid chlorine</td>
<td>Sodium hypochlorite</td>
<td>20 parts per million (ppm) chlorine (0.2ml of 12.5% solution per litre, or 2ml per 10l)</td>
<td>Needs adjusting down to 6 – 8.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Add citric acid or hydrochloric acid (available from pool shops) at approx 0.005g/l, to make sure the chlorine works.</td>
</tr>
<tr>
<td>Nylate®, a chloro-bromo compound</td>
<td>BCDMH, bromo-chloro-dimethylhydantoin</td>
<td>10ppm chlorine, or slightly lower concentrations recommended for spas (see label)</td>
<td>6.5 and 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Usually does not need adjusting.</td>
</tr>
</tbody>
</table>

The concentrations of stabilised pool chlorine, calcium hypochlorite and sodium hypochlorite are about 10 times those recommended for swimming pools as written on the product labels. The chlorine concentration can be checked with paper test strips that are specially made to be used in the 50 to 100ppm chlorine range.

Concentration and pH of chlorine solutions can be measured with test strips.
The pH can be tested with paper test strips from pool shops and adjusted with citric acid at 0.005g/l or 5g (1 teaspoon) per 1000l, depending on the original pH of the water. Flower solutions with their high chlorine concentration need more acid to bring the pH down than swimming pools do.

Household bleach is not recommended because the amount of chlorine in it is not always known and often alkali is added making the pH very high.

These germicides can all be used continuously. Flowers only rarely show damage from continuous chlorine treatment at these concentrations - but try them carefully at first.

Chlorine compounds are used up and broken down by organic matter, sunlight and heat. Usually a solution made to the above concentrations, with flower stems placed in it, will work for one or two days, unless the water or stems are very dirty.

Chlorine germicides can be used with sugar, but not with STS or wetting agents. It is best not to mix them with the strong citric acid used as a hydrating solution (see below), because chlorine solutions are unstable and don’t work as well when they are made acidic.

### Recipe: Chlorine germicide using stabilised pool chlorine

Need 0.1g chlorine powder per 1l of water.

Add the chlorine to the water and stir. It takes a few minutes with occasional stirring to dissolve.

To make up larger amounts than 1l, multiply the 0.1g of chlorine by the number of litres of water e.g.

<table>
<thead>
<tr>
<th>Chlorine (g)</th>
<th>Water (l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>1</td>
</tr>
<tr>
<td>0.4</td>
<td>4</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>100</td>
<td>1000</td>
</tr>
</tbody>
</table>

Note: 1g = ¼ teaspoon  
10g = 2½ teaspoons  
100g = a little more than ½ cup

For information on other germicides, see Section 5.5.

For suppliers of chlorine compounds and other germicides, see Section 5.18.
Hydrating solutions

These are solutions that help the flower to take up water. The major types of hydrating solutions are:

- acids, e.g. citric acid
- wetting agents
- some commercial hydrating solutions.

Each of these solutions has advantages, disadvantages and safety issues – these are detailed in Section 5.

Warm water (i.e. 40°C), ice-cold water (0°C) and deep water (e.g. 20cm) also improve water uptake.

Hydrating with citric acid

The simplest, all-purpose hydrating solution that works well, is citric acid at 0.2g/l. This lowers the water pH to approximately 3.5 to 4.

Citric acid can be used continuously on most flowers, although a few are damaged by continuous treatments (e.g. roses). Citric acid also has a good effect if used as a short treatment for just a few hours.

Citric acid is probably best used by itself, without a germicide. It should be used only once, for less than a day, and the water and containers should be clean.

Recipe: Citric acid for hydrating flowers
Need 0.2g citric acid powder per 1l of water.

Add the citric acid to the water and stir. It takes a few minutes to dissolve.

To make up larger amounts than 1l multiply the 0.2g of citric acid by the number of litres of water e.g.:

- 0.2g citric acid + 1l water
- 0.8g citric acid + 4l water
- 2g citric acid + 10l water
- 20g citric acid + 100l water
- 200g citric acid + 1000l water

Note: 2g = approx. ½ teaspoon
20g = approx. 1 tablespoon
200g = approx. 1 cup
For information on other hydrating solutions, see Section 5.5.

For suppliers of citric acid and other hydrating solutions, see Section 5.18.

Sugar

The benefit of sugar treatment of flowers varies a lot. Most wildflowers do not benefit, but *Anigozanthos* and *Blandfordia* are two that do. The benefits of sugar treatment are (a) improved flower opening, particularly if flowers are picked early with a lot of buds and (b) improved quality after dry transport.

The best sugar concentrations and treatment times also vary. Flowers are usually placed in sugar solutions for 12 to 24 hours at room temperature (15°C to 25°C) or in the cold room. The concentrations used vary from 10g/l (1%) to around 200g/l (20%). It is best to use common table sugar (sucrose), but *Protea* may benefit from glucose (see Section 4).

Remember - Sugar solutions need to have a germicide present to stop bacteria growing. Any of the germicides listed in the Section above are suitable.

Commercial postharvest solutions also provide an easy method of supplying low doses of sugar (1% to 2%). Some manufacturers also make bud-opening solutions with high levels of sugar that could be used to treat flowers like *Anigozanthos* and *Blandfordia*.

Sugar solutions can also cause problems. Some flowers are damaged by too much sugar, while others produce more nectar, which encourages *Botrytis* growth (e.g. *Chamelaucium* and *Telopea*). Also, spilled solutions attract ants.
Recipe: Sugar solution – low concentration (1%) – plus chlorine germicide

Need 10g sugar per 1l water, plus 0.1g stabilised pool chlorine per 1l of water.

Add the sugar and chlorine separately to the water and stir. It takes a few minutes, with occasional stirring, to dissolve.

To make up larger amounts than 1l multiply the 10g of sugar and 0.1g of chlorine by the number of litres of water eg:
- 10g sugar + 0.1g chlorine + 1l water
- 40g sugar + 0.4g chlorine + 4l water
- 100g sugar + 1g chlorine + 10l water
- 1kg sugar + 10g chlorine + 100l water
- 10kg sugar + 100g chlorine + 1000l water

Note: 10g sugar = 2 teaspoons
  - 100g sugar = ½ cup
  - 1g stabilised pool chlorine = ¼ teaspoon
  - 10g stabilised pool chlorine = 2½ teaspoons
  - 100g stabilised pool chlorine = a little more than ½ cup

Recipe: Sugar solution – high concentration (10%) – plus chlorine germicide

Need 100g sugar per 1l of water, plus 0.1g stabilised pool chlorine per 1l of water.

Add the sugar and chlorine separately to the water and stir. It takes a few minutes, with occasional stirring, to dissolve.

To make up larger amounts than 1l multiply the 100g of sugar and 0.1g of chlorine by the number of litres of water eg:
- 100g sugar + 0.1g chlorine + 1l water
- 400g sugar + 0.4g chlorine + 4l water
- 1kg sugar + 1g chlorine + 10l water
- 10kg sugar + 10g chlorine + 100l water
- 100kg sugar + 100g chlorine + 1000l water

Note: 100g sugar = ½ cup
  - 1g stabilised pool chlorine = ¼ teaspoon
  - 10g stabilised pool chlorine = 2½ teaspoons
  - 100g stabilised pool chlorine = a little more than ½ cup
Commercial postharvest solutions and flower foods

The term "postharvest solutions" refers to those products used in bulk by growers, wholesalers, exporters and importers.

The term "flower food" refers to the products that are made for use in vases, by retailers and customers.

These provide an easy, accurate, sometimes well-proven and often economical treatment for flowers. A wide range of commercial products is available, from general purpose solutions to special purpose solutions e.g. bud opening, anti-ethylene treatments, hydrating solutions and solutions for specific flowers. The most commonly available products and their suppliers are listed in Section 5.5 and Section 5.18.

Preparing and using postharvest solutions

Here are ways to make it easy to make up accurate solutions.

- Put marks on the containers/buckets you use, to show where to fill water to. Make sure you know what volume that is, and how much germicide or postharvest solution needs to be added.
- Use clean buckets or other containers.
- Use clean water – no dirt, salt or microbes.
- Label buckets “Postharvest solution only”, “Germicide”, or “Hydrating solution”.
- Make up larger volumes in a large tank or bath.
- Consider putting in a dispensing system if regularly using large volumes of solution. A dispensing system is an automatic way of measuring and delivering the solution. Automatic chlorinators are available from swimming pool shops. Some manufacturers of postharvest solutions also sell dispensing systems – see Section 5.18.
Safe use of postharvest solutions

Follow these safety instructions when using postharvest solutions.

- Handle all dry ingredients and solutions with care. Avoid contact with dry materials and minimise contact with solutions.
- Avoid breathing the vapours.
- Follow the directions on labels.
- Keep dry ingredients dry.
- Store chlorine germicides in a different cupboard from other products because they are strong oxidising agents and can explode if they react with some other compounds.

The diluted or watered-down solutions that flowers are placed in are mostly harmless (except for STS). For example chlorine germicides, citric acid, wetting agents/detergents and sugar solutions are often used in homes and workplaces. However, care does need to be taken to avoid unnecessary contact.

Disposal of postharvest solutions

Check with your local sewerage authority about disposal options. Solutions that are not hazardous, such as dilute postharvest solutions (other than STS), can sometimes be disposed of into the sewer if the business has a trade waste agreement with the local sewage authority. Check with your local catchment management authorities, EPA or local council to see if you need a permit. Postharvest solutions can generally be disposed of by land irrigation as long as this does not pollute surface or ground water.

2.8 Grading and bunching

This processing is generally done in one of the following orders.

- Grade and sort, cut to length, strip leaves, then bunch.
- Grade and sort, strip leaves, bunch, then cut.

Using gloves during this process is recommended.

Grading

Grading is sorting the flowers according to quality and according to the specific requirements of your buyer.
It may be worth having written information and photographs that show your own grading standards. Train your staff to use this information and know the grading standards required.

There are some published quality grades/standards that can be used as guides. See Section 5.7.

Grading is often done on the basis of:
- stem length
- stem thickness
- flower and foliage color
- flower maturity, e.g. extent of opening, number of individual flowers open on a stem
- shape of flower and/or stem; stem straightness
- no sign of defects, pests and diseases.

You may need to downgrade, or throw away, flowers of poor quality. This may be due to:
- pest or disease damage
- defects and deformities, e.g. damaged leaves, yellow leaves, bent stems, a large angle between the stem and flower head, non-symmetrical flowers, flower drop
- thin or thick stems
- stems where individual flowers are wilted or too open.

Many export markets require longer stems than are necessary for many local markets, e.g. more than 50cm.

You may need to remove soft tip growth, side or by-pass shoots, damaged or yellow leaves, and black leaves on proteas.

Often leaves will need to be stripped, especially those that will be under water in a bucket or vase. This can mean 25% to 50% of the leaves. Some markets want one-third to one-half of the leaves stripped on longer stems, e.g. 60cm, especially if leaves are bulky.
Bunching

Bunching also needs to be done to meet the customers’ requirements. There needs to be the same quality within a bunch e.g. stem length, stem thickness, amount of flower opening. One bad stem makes a bad bunch! Bunches need to be compact, look good and fit well into boxes.

Bunch size depends on what the market wants.

- Big flowers are often sold as a single stem e.g. king proteas and banksias.
- Medium flowers are often sold in bunches of 5 e.g. *Protea, Leucospermum*, though these may also be sold as singles on the export market.
- Thinner stems and foliage are often bunched in 10s.
- Some are sold in bunches by weight e.g. *Chamelaucium*.
- Mixed bunches for local market, wholesalers or supermarkets.

All the stems need to reach the bottom of the bunch. Place bands 10cm above the base to make it easier to recut the stems. Bands can be spread to hold the bunch together.

Sleeves protect flowers from damage and drying out, but may increase *Botrytis* growth. For example, *Leucospermum* and *Grevillea* can be sleeved with plastic or paper to prevent their pin-like styles from tangling.

Keep written instructions on the bunching procedure and train staff to do it well.

Cleanliness

Keep the grading and bunching area clean. Remove waste and clean the benches, floors and buckets/containers at least every day.
Quick and easy handling

Labor for grading, bunching and packing is a large cost. Every time a stem is handled, an extra cost equal to the cost of growing the flower is added.

Try to make sure the flow of flowers is even, to avoid flowers piling up and staff either waiting or being rushed. See that staff have good working conditions, lighting, floor mats, and cooling or heating.

As the amount of flowers being handled increases, try to put some of these improvements in place.

- Use large containers for flowers and water (even troughs on wheels).
- Use pallets or racks to move lots of buckets and cartons around on.
- Use a roller conveyor to move things, e.g. cartons from the packing bench to the cold room.
- Consider grading and bunching in the field if it isn't too hot.
- Consider other ways of automating grading, bunching, packaging and handling.

Equipment

Here is some of the equipment that is needed for grading and bunching.

- Good lighting over benches.
- Secateurs (even power secateurs), guillotine, knives.
- Buckets/containers, e.g. three sizes such as 10, 15 and 20l buckets for small-scale operations. White buckets make it easy to see if they are dirty! Buckets may need to be marked with a volume so that postharvest solutions can be made up easily and accurately.
- A place to wash and clean buckets.
- Drains to remove excess water.
- Benches, including movable benches, with easily cleaned surfaces.
- Weighing and measuring equipment for making up postharvest solutions e.g.: balance, spoons, cups, measuring cylinder, dropper, pipette.
• Leaf stripping machines.
• Pallets, pallet trolleys, fork lifts (battery, not gas).
• Scales for weighing bunches and cartons.
• Banding machine for bunches.
• Strapping machine for cartons.
• Rubbish bins.

Keep good records of what is picked, packed, thrown away and sold. These can be linked to information on production and prices received, and to an invoicing system. This information can be used to plan production and marketing better in future. See Work Sheet 2, Section 6.

2.9 Pest and disease control

Growers, exporters and wholesalers need to know what their market wants. For example, most export markets will not accept any pests or diseases. Japan requires that there are no live insects. Just one insect in a delivery is likely to lead to expensive and damaging fumigation! Even dead insects can make some very careful inspectors insist on fumigation.

Flowers are inspected very carefully for insects in export markets.
Exporters must also be aware of the quarantine requirements of importing countries. For example, most require an Australian Phytosanitary Certificate issued by inspectors from Australian Quarantine Inspection Service (AQIS). Find out the requirements from your importer, or from AQIS.

Flowers that are to be sold on the local market may not need postharvest pest and disease treatment.

Some common pests are:

- bees, wasps and ants, which don’t damage flowers but cause rejection by importing countries
- beetles
- caterpillars e.g. Banksia boring moth
- gall-forming wasps damage Chamelaucium in some locations
- grasshoppers
- sucking insects, scale, sucking bugs
- spiders
- snails
- thrips, which can cause surface damage or distort growth – common on Chamelaucium
- weevils (adults) cause major damage in some Proteaceae, particularly Leucadendron.

The most common fungal diseases are:

- Botrytis cinerea or grey mould and Alternaria on flowers
- other fungal diseases that make leaves or stems unattractive or cause importing countries to reject the flowers, e.g. Elsinoe rust on Protea, Puccinia rust on Boronia, Pleospora (Alternaria or Stemphylium) on Chamelaucium

**Use of agricultural chemicals**

When choosing an insecticide spray, dip or gas (fumigant), or a fungicide, ask the following questions.

- Which chemicals will kill the particular pest or disease on your crop?
- What products are registered by the National Registration Authority for Agricultural and Veterinary Chemicals (NRA) for use on the crop (ornamental crops, wildflowers, plant material) against that pest or disease?
- Are the chemicals registered and approved for use in the state?
- Are the chemicals registered and approved for the particular use, e.g. spraying, dipping, fumigating?
- Are the chemicals safe or toxic to humans?
- What is the cost of the chemicals?
The regulation and registration of agricultural chemical use is complex. It is wise to get advice from a specialist at the National Registration Authority for Agricultural and Veterinary Chemicals (NRA), local Departments of Agriculture, Primary Industries, Environment Protection Authority (EPA) or equivalent, or from a knowledgeable, responsible chemical sales person. A list of contacts for advice on agricultural chemicals is given in Section 5.8.

These are some of the issues of agricultural chemical use that you need to be aware of.

- Almost all chemicals used in agriculture need to be registered by the NRA. The approved labels include instructions for proper use.
- Certain off-label uses of chemicals are only allowed with a permit from the NRA. This can include the use of unregistered chemicals, the use of a registered chemical for a minor use, to treat minor crops, or for a use that is not included on the product’s label.
- Some states allow off-label use, e.g. for different crops and different uses, without the need for a permit from the NRA. Check with individual states for their requirements. For example, Victorian law allows certain off-label use of certain registered chemicals (other crops, uses not included on the label and uses for which there is no suitable registered product) without the need for a permit from the NRA. Chemicals that are excluded from this are those that contain Schedule 7 poisons and atrazine, metham sodium, and ester formulations of MCPA, 2,4-D and triclopyr. Other situations where off-label use is excluded in Victoria are where the use is prohibited by Victorian law and where the label prohibits the use e.g. “Do NOT apply by back-mounted spray equipment”. In using a chemical off-label the user assumes the responsibility for use. Contact the Victorian Chemical Information Service for further information, phone (03) 9210 9379.
- In NSW, off-label use without a permit from the NRA is not approved. In NSW, correct and safe application of farm chemicals is required by law. The user is responsible for choosing the correct chemical and rate of application. NSW individuals found using pesticides contrary to label direction can face prosecution and large fines.
- In Queensland it is illegal to use chemicals that are not registered and approved for the crop or broad category of crop (e.g. ornamentals or wildflowers) concerned.
- All aspects of off-label use are the user’s responsibility, including residues, environmental safeguards and occupational health and safety. Chemicals used off-label are not necessarily covered by the manufacturer’s warranty.
- In Victoria, an Agricultural Chemical Users Permit is required for all use of chemicals that contain Schedule 7 poisons and for several other chemicals. A prerequisite for a permit is a recognised qualification such as a Farm Chemical Users Course. Check the requirements in the state.

For further information on use of agricultural chemicals see Section 5.8 and Section 5.9.
Field control of pests and diseases

The best place to control pests and diseases on flowers is in the field. It is important to regularly look for pests and diseases. Where possible infected material should be removed from the field and burned. Where necessary apply insecticide or fungicide sprays that are registered to control insects and fungi on flowers or ornamentals.

For more information on control of pests in the field, see Woods, Seaton and Grimm (1996) and AFPGA (2000).

There are many fungicides registered for use on ornamental crops. For example, those registered for use against *Botrytis cinerea* or grey mould contain the active ingredient iprodione, chlorothalonil or pyremethanil.

Frequent field sprays of fungicides and insecticides can lead to resistance, so it is important to vary the chemicals used. For example, a benomyl resistant strain of *Botrytis cinerea* has been isolated from *Chamelaucium uncinatum*. Where postharvest use is approved, e.g. iprodione use in NSW and QLD, reserve iprodione for postharvest use.

When flowers are bush-picked, it is hard to control insects, because there is a large range of flowers and insect species present. Insects will continually invade from surrounding bush. In regenerating bush and areas of a single species, insecticide sprays may be effective.

Insecticide dips

Some states have NRA registration, NRA off-label permits, or state off-label approvals for certain insecticides to be used as postharvest dips. Ask you state Department of Agriculture, Primary Industries, EPA or Chemical Information Service for advice on what insecticides are registered and approved for this use in your state. A list of contacts for advice on agricultural chemicals is given in Section 5.8

Insecticide fumigation

There are two types of registered insecticide for fumigation.

- Phosphine gas.
- Methyl bromide.

At least one state has off-label approvals for certain registered insecticides to be used as fumigants. Ask you state Department of Agriculture, Primary Industries, EPA or Chemical Information Service for advice on what insecticides are registered and approved for this use in your state. A list of contacts for advice on agricultural chemicals is given in Section 5.8.
Phosphine

This is a new fumigant for cut flowers, e.g. ECO₂FUME® (BOC gases), which requires a treatment time of 15 hours at 15°C. It is best applied to flowers in buckets/containers, not in cartons. Refer to the product label.

Methyl bromide

Methyl bromide (MB) can be applied for a short time (3 hours) at 10°C to 15°C. Refer to the product label. It can be applied to exposed or packaged flowers. However, MB often injures flowers. In one experiment, it caused flower drop from *Chameliaucium uncinatum*, but no damage to *Banksia prionotes*. It may be particularly useful for dried flowers.

To use MB, you need to have formal training in safe fumigation. For further information, contact the Chemical Information Service or a similar service in your local Department of Agriculture/Primary Industries or the Environment Protection Authority (EPA) (see Section 5.8).

MB is likely to become unavailable for many uses by 2005 because it is an ozone destroyer.

Fumigation methods

Before starting a large-scale fumigation program, do a test run to see if the chosen method does kill the insects and whether the flowers are damaged at all.

Great care needs to be taken when using phosphine and methyl bromide. They are highly toxic and can be deadly to humans. Death can result from brief exposure to high concentrations. The benefit of fumigation is that the dangerous chemicals can be kept to a closed chamber.

Fumigation can be done by a grower, at a central packing house, by an exporter or wholesaler, or by a pest control company. It is probably best to fumigate as the last step before (or after) packaging and before cooling and transporting. The fumigation time could also be used to supply flowers with hydrating solutions or postharvest solutions.

Fumigation rooms and their equipment are a special facility. They need to be built carefully. They should be away from other working areas. They need to:

- be air tight
- have a fumigant delivery system (often supplied with the fumigant)
- have a way of circulating the fumigant
- possibly have a heater
- have a way of getting rid of the fumigant from the room after treatment
- display signs to tell people that fumigation is going on
- be run by trained, qualified staff. Users of phosphine and methyl bromide need to have an agricultural chemical user permit (ACUP) in Victoria.
Keep good records of what flowers were fumigated, what insecticide was used, at what rate, the temperature and time and whether any damage occurred. See Work Sheet 5, Section 6.

For more details on pesticide fumigation see Section 5.9.

**Other pest control issues**

- If there are only a few, obvious, easily killed insects in a delivery, it may be possible to kill them with a spray can of household insecticide. Check to see that it doesn't damage flowers.
- Some careful exporters may transport their flowers in cartons that have insect-proof gauze over the holes at the end of the boxes, to prevent insects getting into the cartons.
- Pest strips placed in cartons after fumigation and before export, to kill any insects that come into the boxes in transit, do not usually work well.
- Keep good records of the pesticides used both before and after harvest.
Disease control

The main disease affecting the postharvest life of wildflowers is *Botrytis cinerea*, which causes grey mould disease. *Botrytis* grows on flowers in the field under cool, damp conditions. It then grows quickly under moist conditions and changing temperatures after harvest.

*Botrytis* damages petals and causes ethylene production and flower drop on some flowers, such as *Chamelaucium uncinatum*. *Botrytis* has also been identified on *Leptospermum*, *Leucospermum* and *Telopea* and is suspected to be present on *Thryptomene calycina*, *Eriostemon* and other flowers. The first signs of it on *Chamelaucium uncinatum* are tan areas at the base of petals, but it is likely to be there, and causing damage even before this can be seen. It goes on to become a grey mould covering the flower. Flowers showing signs of *Botrytis* infection should not be sold, as it will only get worse.

It is necessary to keep packing sheds clean, and remove and destroy any *Botrytis* infected material.

If flowers are kept dry (90% RH) and cold (less than 10°C) it will minimise *Botrytis* growth. Packing bunches dry, keeping forced-air cooling holes on boxes open and careful placement of extra air holes can all reduce *Botrytis* growth and flower drop.

Effects of cold on flower drop from *Chamelaucium uncinatum*, caused by *Botrytis*.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Flower drop %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated, 20°C</td>
<td>29</td>
</tr>
<tr>
<td>Untreated, 2°C</td>
<td>5</td>
</tr>
</tbody>
</table>

*Pleospora* fungus (forms of *Alternaria* and *Stemphylium*) is also a problem on *Chamelaucium* as it grows during export.
**Fungicides**

There are many fungicides registered for use on ornamental crops. For example, some active ingredients that are registered for use against *Botrytis cinerea* or grey mould are iprodione, pyremethanil and chlorothalonil.

Some states have NRA off-label permits, or state off-label approvals for certain fungicides to be used as postharvest dips. Ask your state Department of Agriculture, Primary Industries, EPA or Chemical Information Service for advice on what insecticides are registered and approved for this use in your state. A list of contacts for advice on agricultural chemicals is given in Section 5.8.

### 2.10 Packaging

**Choosing a package**

Choose a package that:

- gives your customer what they want – package type, size, appearance
- protects your flowers
- is efficient to handle e.g. not too heavy, fits on pallets
- is easy to pack
- allows for forced-air cooling, if that is used
- prevents flowers from warming up or drying out
- displays the flowers well
- is not too expensive
- provides holes to allow fumigation in the market country, if required (e.g. Japan)
- can be reused, or recycled if the market requires recyclable cartons.

The packaging options include: buckets, cartons, buckets in cartons, “wet pack” cartons that hold water, plastic sleeves, polystyrene boxes.

Local market cartons are often large, one-piece and not very strong. Export cartons are usually two-piece and come in a range of sizes to suit the market and flowers e.g. 12, 10, 5, 3.6 and 1.6kg cartons.

**Packing flowers**

Consider each of these points when packaging.

- Get the right balance between fitting as many flowers as possible into a package and not putting so many in that they are damaged, look terrible or overheat.
- Don’t mix flowers, stem lengths or different quality/grades in one carton.
- See that the flowers and stems are dry before packing species where wetness causes damage, e.g. *Protea.*
• Use paper or plastic carton liners to help protect flowers and stop them from drying out. Some cartons include a layer of plastic in the carton (e.g. Amcor Barriercote cartons).

![Image: Packing Chamelaucium. Note paper liner.](image1)

![Image: Leucospermum with plastic carton liner.](image2)

• Pack flowers tightly into the carton as this is the best and most economical way to hold flowers in place. If this is not possible, use rubber bands, cardboard strips or plastic rods attached to the sides of the carton to hold flowers down. Bands, or tape can hold down the carton lid.

• Use sleeves, or sheets of plastic or paper to separate bunches or layers of flowers to prevent their pin-like styles from inter-locking and getting damaged.

• For export, pack as many flowers as possible into a carton without damaging them. Freight rates are usually calculated on volume rather than actual weight as flowers are light. This will minimise freight costs per stem.

• Use a packing pattern that’s easy to use, gets as many flowers as possible into the carton and minimises movement of flowers within the carton. Compressing the flowers and inter-weaving the stems reduces movement.

![Image: Leucospermum with shredded paper to protect heads.](image3)

![Image: Fit as many flowers as possible into a carton without causing damage or overheating.](image4)
Keeping packed flowers cold

Packed flowers can be kept cold by keeping them in a cold room. However, once they are packed in cartons it is very difficult to cool them more unless forced-air cooling is used (see Section 5.3). When using forced-air cooling take note of these points.

- Cartons need to have holes in each end or each side. The holes need to occupy 5 to 6% of the sides or the ends of the carton.
- Flowers need to be packed so that air can move through them.
- Holes can be covered with the carton flaps or labels once the flowers have been cooled. However, if the flowers are going into a hot environment it may be better to leave the holes open so that the flowers don’t overheat.

Placing ice or ice-gel packs in packages to keep the flowers cold only works if the packages are very well insulated from warm air outside. If regular cartons are held at 20°C, the small amounts of ice/gel that are usually placed in regular uninsulated cartons (e.g. 500g to 1kg) melt and stop working in less than 24 hours.

Groups of packages can be covered with an insulating material to keep heat (or cold) out. For example a sheet of polystyrene (50mm) underneath a stack of cartons can dramatically reduce heat entering the cartons from hot roads, trucks or tarmacs; a layer of builders foil, or a special insulating blanket, over the top of a pallet load of cartons, or lining the inside of an air freight container, can keep heat out.

Labelling and branding

Cartons need to be labelled with the following information.

- The address it is going to and the address it has come from.
- How many cartons are in the delivery.
- A description of the contents (type of flower, length, color, grade, quantity).
- Instructions/information such as “Perishable Cargo”, “Fresh Flowers”, “Fragile”, “This way up”, “Keep cool at all times”, “Store between 2°C and 4°C”, “Handle with care”.
- More detailed instructions about re-cooling, recutting stems, and using postharvest solutions. For export flowers, these instructions can also be written in the language of the importing country.

Usually an invoice needs to be attached.

Cartons also provide a great opportunity to display your brand and business name.
Transporting packages

When packages are grouped together for transport there often needs to be a way of holding them together. They may need:

- nets over a pallet of cartons
- corner supports for a pallet of cartons
- a way of stopping buckets moving.

Handling instructions are marked clearly on the carton.

A pallet of flower cartons needs corner supports and straps.

2.11 Transporting

Transport needs to be quick, cold and gentle to avoid too much loss of quality. It is also important that the flowers don’t come in contact with ethylene during transport e.g. from ripe fruit or exhausts from forklifts, trucks or aeroplanes. Temperature loggers or temperature sensitive labels (see Section 5.3) can measure the temperature of the flowers during transport.

Temperature logger measures temperature during transport.
After transport, flowers should be cooled and often need to be recut and placed in water.

Transport is expensive, particularly air freight, so it is important to get as many flowers as possible into the transport space being used (i.e. the carton or air freight container), without going over the weight limits on air freight containers and without crushing the flowers.

**Road, rail and sea transport**

With these forms of transport, temperature control can be good, but the time taken to deliver the flowers may be long. Flowers need to be cold before they are loaded into the truck/container. The transport refrigeration system and air delivery system need to be well designed to get the cold air going through the whole load. The container needs to be well insulated so extreme outside temperatures don’t warm the load. The flowers need to be placed carefully into the container so airflow is not restricted. If you can’t use refrigerated transport, try to organise transport in the cool times of the day, like night or early morning.

**Air transport**

With air transport, temperature control is often poor and flowers can get too hot, but the journey is quick. Before, after and during flights, conditions can be hot or freezing. The temperature in aircraft storage areas is usually about 15°C.
Flowers need to be cooled before they are sent on for air transport. If the cold flowers can be insulated from the outside heat or extreme cold during transport, it is an advantage (e.g. insulation under and over a pallet or inside air containers). Cold room facilities are available at only some airports, and can also keep flowers cold. Flowers shouldn't be left on airport tarmacs, at the departure place, during transhipping, or at the end of the journey. Soon, refrigerated air containers will be available, but they will be expensive.

2.12 Holding flowers before selling

Flowers should be held for as short a time as possible before passing them on to your customer. They should be kept cold, at 2°C to 4°C, with their stems in water containing a germicide or flower food. Flowers can be held dry in packages (e.g. cartons) as long as the packaging prevents the flowers from drying out and the flowers are kept cold.

2.13 Wholesalers on local markets

Wholesalers may need to apply the following treatments to flowers.

- Give water to flowers after a period of dry transport. Recut stems and place the flowers in a hydrating solution, germicide, or commercial postharvest solution.
- Apply anti-ethylene and pest and disease treatments, if the flowers have not already had these (see above for details).
- Cool the flowers before they are sent on and keep them cool.
- Avoid contact with ethylene (ripe fruit, engine exhausts, banana ripening rooms) during storage or transport.

Wholesalers may re-bunch and re-package flowers to meet needs of their customers, e.g. making up mixed bunches.

Flowers should be sold and sent on as quickly as possible.
2.14 Exporting

Some treatments may need to be applied by the exporter. They may need to do some or all of the following.

- Apply water to the flowers after a period of dry transport.
- Recut stems and place the flowers in a hydrating solution, germicide, or commercial postharvest solution.
- Apply anti-ethylene and pest and disease treatments if the flowers have not had these.
- Sort, grade and pack flowers if necessary, to meet orders and consolidate a load.
- Keep flowers cool. Cool flowers before transporting.
- Make sure flowers don’t come in contact with ethylene from ripe fruit, engine exhausts, banana ripening rooms etc.

Exporters also sell the flowers and arrange export licences and authorities, AQIS inspection, freight forwarding and air freight and combine loads. See Section 5.12 for more information on exporting.

2.15 Shipping

Freight forwarder

A freight forwarder is not essential, but can be helpful in getting air freight space at good rates. They can also combine loads, see that labelling and paper work is correct and deliver the flowers to the airline just in time.

The freight forwarder can cool flowers before air freight, preferably using a forced-air cooler. They can also make sure that freight containers are covered with an insulating blanket while they are on the ground, or lined with an insulating material, to help keep flowers cool.

Freight forwarders also need to make sure that flowers do not come in contact with ethylene.

Airline

An airline needs to handle flowers quickly and gently, and keep them cold. A cold room at the air terminal is very valuable. It is essential that flowers do not sit on the tarmac in the sun, or on ice, for any longer than is absolutely necessary. Flowers should not come in contact with any ethylene risks.
2.16 Importing

Flowers may have to be fumigated at the exporter's expense. Often such fumigation damages the flowers. In some cases, the exporter has the choice to fumigate or lose the flowers.

Importers should at least cool the flowers, by placing them in a cold room, preferably with forced-air cooling. If the importer markets the flowers with stems in water, then the stems should be recut and placed in a hydrating solution or commercial postharvest solution. The importer also needs to make sure that the flowers do not come in contact with ethylene from ripe fruit, engine exhausts, or banana ripening rooms etc.

2.17 Wholesalers in importing countries

The wholesaler is the ‘key person’ for the cut flower industry in the importing country. The wholesaler may need to:

- cool the flowers if that has not already been done
- water the flowers, if that has not been done, by recutting stems and placing them in a hydrating solution or commercial postharvest solution
- sort, grade, bunch and package the flowers to meet needs of their customers e.g. making up mixed bouquets for supermarket chains
- make sure flowers don’t come in contact with ethylene from ripe fruit, engine exhausts, or banana ripening rooms etc.
- keep flowers in cold store for some time to manage the supply to their customers
- cool before sending on.
2.18 Retailing

Receiving flowers

When flowers come in, the retailer needs to do these things.

- Check the quality of incoming flowers as some might need to be thrown out.
- Recut stems, under water if possible.
- Remove leaves that will be under water.
- Place flowers in postharvest solution or flower food in clean containers.
- Place flowers in a cold room that has high humidity and low air movement, if they won't be sold immediately.
- Cover the flowers, e.g. with plastic, to reduce drying out.

Displaying flowers

When displaying the flowers, the retailer needs to do these things.

- Try to keep flowers out of hot windy places and away from ripe fruit or engine exhausts.
- Be careful when misting flowers to keep them moist. It is probably not a good idea to do this to flowers that might have *Botrytis* fungus, such as *Chamelauclium* (and roses and gypsophila), as it will help the growth of the fungus, and spoil the flowers.
- Soak all flower foam used for arrangements in flower food solution for several hours before it is used. This helps to make sure that the flowers have a good supply of water and flower food in the foam.

Advice to customers

Retailers can include a packet of flower food with all sales, or more than one packet with large bouquets and arrangements. They can also provide flower care instructions, as a card, on the flower sleeve, or on the flower food packet.

There are many commercial cut flower foods.
Flower care advice

Remove leaves that will be under water.

Add a sachet of flower food, from your florist, to water in a clean, deep vase.

Cut 2cm off stems, with a sharp knife, scissors or secateurs, preferably under water.

Arrange flowers in the vase.

Keep flowers out of hot, sunny, windy places.

Keep the vase filled (or floral foam soaked) with water containing a flower food.

If flower food is not used, recut the stems and renew the water every two to three days.
2.19 How good are your flowers?

Keep a sample of the flowers you send to your customer to see how well they keep.

You can even put them through simulated or “mock” wholesaling or export (e.g. 3 days at 15°C in a carton) and then into a vase, or directly into a vase. Take note of the following things.

- How they recover from the “mock” wholesaling/export.
- If they open.
- Any pests and diseases on them.
- If there is any flower drop or wilting.
- The length of vase life. See Section 5.13 for standard vase life evaluation conditions.

Unless you do this, you won’t really know how well your flowers perform in the handling chain to the consumer.
3. A general postharvest treatment method

3.1 Harvesting

- Pick at the stage of opening or maturity that your market wants, or a little earlier, as individual flowers on a stem may open during marketing.
- Cut stems with sharp secateurs, or other cutters.
- Place into a suitable container, with water if possible, and with either a germicide, a hydrating solution or a commercial postharvest solution in it.
- Place flowers in the shade where possible. For example, artificial shade could be used over a trailer.
- Transport to the packing shed within an hour of picking, or sooner if the temperature is greater than 20°C or if flowers are not in water.
- Put flowers into water after harvest and give some or all of the following treatments: cooling, anti-ethylene treatments, postharvest solutions and pest and disease control treatments.
- After harvest, place dry-handled flowers into water and then handle them as above, or keep them dry and give some or all of the following treatments: anti-ethylene treatment, pest and disease treatments, or grading and bunching.

3.2 Cooling

- Remove the field heat as soon as possible after harvest and/or after grading and bunching, e.g. within an hour of harvest, by placing in a cold room.
- Keep temperature for most flowers at 2°C to 4°C as long as there is no risk of freezing.
- Cool packaged flowers by using forced-air cooling before transport.
- Apply anti-ethylene treatments, postharvest solutions or pesticide fumigation to flowers while they are cooling with their stems in water.

3.3 Ethylene and anti-ethylene treatments

- Avoid exposing sensitive flowers to ethylene from ripe fruit, engine exhausts from cars, fork-lifts or aeroplanes, and from banana ripening rooms. Good ventilation often avoids ethylene exposure.
- Apply anti-ethylene treatments if ethylene sensitive flowers are producing their own ethylene, because they are aging or infected with Botrytis.
- Apply anti-ethylene treatments if ethylene sensitive flowers are likely to come in contact with ethylene.
- Use one of the following treatments for blocking ethylene action:
  - silver thiosulphate (STS) and commercial treatments containing STS
  - 1-MCP, a new treatment applied as a fumigant.
- Keep temperature low to reduce ethylene production and the damaging effects of ethylene.
3.4 **Postharvest solutions**

- Place flowers in water after harvest and/or after grading and bunching.
- Recut stems if they have been dry for more than an hour, and quickly place in water or postharvest solution.
- Use clean containers and clean water.
- Use a germicide (such as 0.1g/l stabilised pool chlorine) or a commercial postharvest solution in the water.
- Consider using a specific hydrating solution (such as 0.25g/l citric acid), if flowers have been dry. However, most times, a general purpose postharvest solution will do.
- Rarely add sugar to postharvest solutions. As a rule, there are few benefits from adding sugar for wildflowers. In most cases a general purpose postharvest solution, which usually contains a little sugar, will be adequate.
- Apply anti-ethylene treatments, pest control fumigation and/or cooling while stems of the flowers are in water.

3.5 **Grading and bunching**

- Grade the flowers according to stem length, bunch size, the degree of individual flower opening and any other quality measures required by your market.
- Bunch flowers by number of stems, and occasionally by weight.
- Make sure all flowers within the bunch are uniform in flower maturity and stem length diameter and branching.
- Remove leaves from the lower part of the stem, particularly for large leafed flowers.
- Make up mixed bunches for the local market.

3.6 **Signs of good quality**

- Look for well-colored, evenly colored individual flowers, healthy buds, green leaves, straight stems, minimal bending between stem and flower head.

3.7 **Signs of bad quality**

- Look for damaged or deformed flowers or leaves, insect damage, shrivelled buds, wilted leaves or stems, yellowish leaves, blackened leaves on proteas, bent or damaged stems.

3.8 **Pest and disease control**

- If necessary, use postharvest dips in registered insecticides and/or fungicides (to control Botrytis) where this use is registered and approved. Dry dipped flowers well before packing.
- Otherwise, fumigate with a registered insecticide gas when necessary.
### 3.9 Packaging

- Keep in mind that good packaging provides physical protection, prevents drying, allows efficient handling, allows forced-air cooling and fumigation, presents the flowers well for marketing, adds value to the flowers, may be reused or recycled and is cost effective.
- Consider options such as cartons, buckets and plastic sleeves.
- Make sure that cartons have holes in the end for forced-air cooling, ventilation and to meet Japanese requirements for fumigation.
- Pack the flowers tightly in cartons so they interlock and will not move during transport.
- Line the long sides of the carton with a paper or plastic liner but do not cover the short sides, if forced-air cooling or fumigation will be necessary.
- Make sure that labels show: type of flower, length, color, grade, quantity, messages such as “Perishable Cargo”, “Fresh Flowers”, “Keep cool at all times”, “Store between 2°C and 4°C”, “This way up”, “Fragile”, or “Handle with care.”

### 3.10 Transport

- Make sure that transport is quick, cold (2°C to 4°C) and doesn’t allow the flowers to dry out or come in contact with ethylene (from ripe fruit or engine exhausts).

### 3.11 Holding flowers before sale

- Hold the flowers for the minimum time possible before sending them to your customer.
- Hold them in a cool room (2°C to 4°C), with stems in water and a germicide or commercial flower food.

### 3.12 Exporter or wholesaler

- If the grower has not given cooling, water, flower food, anti-ethylene and pest and disease control, the exporter/wholesaler may need to apply them. If flowers have been dry, they may need to be recut, to ensure water uptake.
- Flowers should be kept cool (2°C to 4°C) while at the exporter/ wholesaler and should be cold when they leave their control.

### 3.13 Shipper (freight forwarder, airline)

- Transport is best if it is quick, cold and doesn’t allow the flowers to dry out or come in contact with ethylene.
- Flowers should be cold before they are transported.
- Flowers should not be in hot or freezing environments.
3.14 Importer and wholesaler

- Importers and wholesalers in importing countries need to sell flowers as quickly as possible and keep them cold (2°C to 4°C) until they are sold. Avoid ethylene (from ripe fruit and engine exhausts) and drying conditions/draughts.
- Importers and wholesalers may recut stems, and put the flowers in water, hydrating solution, or a general-purpose postharvest solution.
- Wholesalers also sort, grade, bunch, package and add value to flowers. They manage the supply of flowers, to their customers’ needs.

3.15 Retailer

- Retailer’s should recut stems, under water if possible, and place flowers in water, with a germicide, hydrating solution or commercial flower food.
- Flowers should be kept cool and sold quickly.
- Ethylene from motor exhaust and ripe fruit should be avoided.

3.16 Customer

- Recut stems, preferably under water if possible. Place flowers in flower food and avoid hot, draughty places.
4. Specific postharvest treatments for individual crops

The following advice on individual crops is in addition to the general treatment methods given in Section 3. When in doubt, use the treatments described in Section 3.

The detailed methods for postharvest treatments are described in Sections 2 and 5.

- Anti-ethylene treatments: Sections 2.6, 5.4 and 5.5.
- Postharvest solution: Sections 2.7 and 5.6.
- Pest and disease control: Section 2.9, 5.9 and 5.10.

We have provided information on the vase life of freshly cut flowers, usually at 20°C, 60 to 70% RH and with 12 hours light per day. However, vase life depends on many factors, so this information should be used as a guide only.

Storage refers to long term cold storage. Most flowers that have a reasonable vase life of 7 days or more can be successfully held for a few days at 2°C to 4°C with their stems in a germicide or commercial solution if necessary.
ACACIA

Botanical name: Acacia species
Common name: Wattle, Mimosa
A range of species can be used.

Harvesting
Branches should have 20% open flowers. Do not pick if the flowers are wet as they will turn brown. Place flowers in water, germicide, hydrating or other postharvest solution in the field.

Ethylene sensitivity
Some are sensitive to high levels of ethylene, which causes flower drop. It is probably not worth applying anti-ethylene treatments.

Postharvest solutions
Use a hydrating solution, for example:

Agral (Agral 600®) at 0.1ml/l (1ml/10l) plus a germicide (e.g. a quaternary ammonium germicide or, if the water is pure, aluminium sulphate at 0.2g/l) for 16 hours at 10°C to 20°C, or at 2°C to 4°C if more than 20% of the buds are open.

Cooling
2°C to 4°C. Cover the flowers to prevent water loss (e.g. with plastic).

Grading and bunching
Flowers are sold 10 stems to a bunch. Stems are usually 50cm long or longer.

Signs of bad quality
Brown flowers, soft shoot tips and drying out.

Pest and disease control
Control pests in the field as fumigation can dry and damage the flowers. Dipping also damages flowers.

Storage
Do not store. Has very short life, so shouldn’t be stored.

Packaging
Use plastic sleeves and carton liners to reduce drying out.

Messages for importers and wholesalers
Stems must be recut and placed in a commercial postharvest or hydrating solution or flower food.
Japanese florists stand stems in near-boiling water and cover with plastic bag until yellow buds open.

**Messages for retailers and consumers**
Use a germicide or commercial postharvest solution.

**Other important considerations**
Select species and forms with better vase life, e.g. *A. buxifolia, A. cultriformis, A. floribunda, A. lanigera* and *A. retinodes*.

French growers pick at the yellow bud stage and force the flowers open (stems in solutions, heads covered, in a warm humid room for more than a day). They keep the heads in a plastic bag and sell the flowers in less than 24 hours. See Sedgley and Horlock (1998).

Allergy: there is a chance of people who handle *Acacia* a lot e.g. growers, becoming allergic, leading to hayfever-like symptoms.

**Vase life of freshly cut flowers**
Most *Acacias* have a very short vase life, although better species and varieties can last 7 to 10 days.
ACTINOTUS

Botanical name: *Actinotus helianthi*
Common name: Flannel flower

Harvesting
The flower heads are ready for harvest when the first 10% to 20% of flowers open in the centre of the head. Cut stems as long as possible, but never into the oldest part of the stem. Pick directly into water containing a germicide, hydrating solution or commercial postharvest solution.

Ethylene sensitivity
Unknown.

Postharvest solutions
Use a hydrating solution or a commercial postharvest solution.

Cooling
2°C to 4°C.

Grading and bunching
Flowers are usually sold 10 stems to a bunch. Stems are usually 40cm long or longer.

Packaging
Sleeves will protect the flower heads and reduce damage. Carton liners (polyethylene or commercial products) maintain quality.

Messages for importers and wholesalers
Recut stems and place into a germicide, commercial postharvest solution, or flower food. Cool the flowers.

Messages for retailers and customers
Recut stems and place into a germicide or flower food.

Other important considerations
Fine hairs on the stems and leaves can cause allergies in some people.

Vase life of freshly cut flowers
Vase life can vary from 7 to 35 days.
ANIGOZANTHOS, MACROPIDIA

Botanical name: Anigozanthos pulcherrimus, A. flavidus, Anigozanthos species, Macropidia fuliginosa
Common name: Kangaroo paw.
There are many varieties and hybrids.

Harvesting
The first one or two individual flowers on each stem should be open. If not they will wilt or not open. Cut stems at least 20cm above ground level.

Ethylene sensitivity
Not sensitive.

Postharvest solutions
Stems will wilt if they dry out, so placing them in water, as soon as possible, is important.
Use at least a germicide or commercial postharvest solution.

Kangaroo paws need a sugar pulse for maximum vase life, but different varieties like different concentrations. Some prefer the sugar as low as 3% while others prefer up to 20% (30 to 200g/l). A. rufus, A. pulcherrimus and Macropidia benefit from 200g/l sugar. Test a range of concentrations to see what is best for each species. Add a germicide. Treat for 12 hours at 20°C to 24°C, or longer at 2°C to 4°C, in a well-lit area. Too much sugar causes leaf blackening and flower drying.

Cooling
2°C to 4°C, not colder. The most common cause of bad quality is lack of cooling, and overheating at all stages of the handling chain.

Grading and bunching
Long stems are usually sold 5 to a bunch. Shorter stems are bunched in 10’s. Stems are usually 70cm long or longer.

Signs of bad quality
Shrivelled unopened buds, wilting.

Pest and disease control
Use postharvest dips in registered insecticides and/or fungicides where this use is registered and approved. Insecticide dips are not always successful. Methyl bromide can damage kangaroo paws.

Your Notes:

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Storage
Kangaroo paws can be stored for a few days (and up to 2 weeks) at 2°C. Fungal infections can be a problem.

Packaging
The flowers are generally sleeved to protect the flowers and to prevent drying out.

Messages for importers and wholesalers
Recut stems and place into a germicide, commercial postharvest solution, or flower food. Cool the flowers.

Messages for retailers and customers
Recut stems and place into a germicide or flower food.

Other important considerations
The labor needed for picking, treating and packing is 8 to 20 people per ha during the main harvest season (Carson 2000).

Some people are allergic to the hairs on the stems.

Vase life of freshly cut flowers
There are large differences in vase life between different species, hybrids and varieties, e.g. 7 to 21 days.
BAECKEA

Botanical name: Baecke species
Common name: Baecke

Harvesting
Harvest when 20 to 50% of the flowers open.

Ethylene sensitivity and anti-ethylene treatments
Baecke virgata is sensitive to ethylene, which causes petal drop. STS protects against this effect of external ethylene. It is not known if B. behrrii is sensitive to ethylene, but STS did not increase natural vase life.

Postharvest solutions
Use a germicide or commercial solution.

Cooling
2°C to 4°C.

Grading and bunching
Flowers are usually sold 10 stems to a bunch or by weight (e.g. 400g). Stems are usually 50cm long or longer.

Signs of bad quality
Petals drop easily.

Messages for importers and wholesalers
Recut stems and place into a germicide, commercial postharvest solution, or flower food. Cool the flowers.

Messages for retailers and customers
Recut stems and place into a germicide or flower food.

Other important considerations
Flowers can drop petals soon after harvest, but after that petal drop can be minimal.

Vase life of freshly cut flowers
Selected varieties of B. behrrii have long vase life (12 to 14 days and little or no petal drop. B. crenulata, B. virgata and B. astartoides appear to have short vase lives (2 to 4 days).
BANKSIA

Botanical name: Banksia species.
Common name: Banksia.
There are many species used as cut flowers, with a number of varieties and a few hybrids.

Harvesting
Harvest when 5 to 10% of the individual flowers open (i.e. pin-like styles stick out). For export, pick with no styles out.
Stems are also cut when the flower heads are still in bud, or have gone to fruit.

Ethylene sensitivity
Not sensitive.

Postharvest solutions
Use a germicide or commercial solution. Sugar treatment does not usually improve quality or vase life.

Cooling
2°C to 4°C.

Grading and bunching
Flowers are usually sold as single stems or in bunches of 5. Stems are usually 50cm long or longer. Remove the lower 10 to 15cm, or 30%, of leaves. Avoid bruising and damage to flower head.

Signs of bad quality
Blackened, dried, diseased or insect damaged leaves.
Dried, faded, or grey-tinged flowers.

Pest and disease control
Avoid dipping as it damages the flower head surface.
Check heads for insects trapped in the flowers (e.g. bees).

Storage
Storage for more than 2 weeks will reduce vase life. B. prionotes stored well for 4 weeks at 0°C to 2°C in closed plastic bags but dried out badly if stored in sleeves or lined cartons.

Packaging
Flower heads can be easily damaged physically. Avoid loose or weak packaging. Pack with heads at each end of the box and stems in the middle. Do not overpack.
Messages for importers and wholesalers
Recut stems and place into a germicide, commercial postharvest solution, or flower food. Cool the flowers.

Messages for retailers and customers
Recut stems and place into a germicide or flower food.

Other important considerations
Avoid packing wet flowers as they develop black streaks.

Vase life of freshly cut flowers
Vase life is approximately 14 days.
BLANDFORDIA

Botanical name: Blandfordia grandiflora.
Common name: NSW Christmas bells.

Harvesting
Harvest for the local market when first two bells on the stem opens. For export, pick the day before the first bell opens.

Ethylene sensitivity
Not sensitive.

Postharvest solutions
Use a germicidal or commercial solution. Sugar treatment of stems picked in bud may increase opening and coloring (e.g. 100g/l sugar plus germicide, overnight at 2°C to 4°C). After a few hours of these solutions, the flowers can be held in clean fresh water.

Cooling
2°C to 4°C. Cool, preferably by forced-air cooling, then close carton vents before shipping. Maintain the cool chain from grower to final customer.

Grading and bunching
Handle gently. Grade for consistent colors in a bunch/box/order. Flowers are sold as single stems or bunches of 5. In NSW, the NPWS require that they are sold in bunches of 5. Stems are usually 50cm or longer. On mature, open flowers, the pollen sacs can be removed to avoid pollen spilling on the flowers.

Signs of bad quality
Bruising.

Pest and disease control
Postharvest pest treatment is necessary. Botrytis infection is common. Use postharvest dips in registered insecticides and/or fungicides where this use is registered and approved.

Storage
Flowers can be stored dry in lined cartons at 1°C to 2°C for 4 weeks but vase life may be less than 7 days. Botrytis is a problem on stored flowers and postharvest fungicide dips should be used in states where they are approved. Commercial attempts at 6 weeks dry storage have failed.
Packaging
Careful packaging methods are essential to hold and protect the flowers. Single stems can be packed in two layers in a shallow tray with the stems held down by strips of polystyrene foam. Each layer can be covered by padding or bubble plastic. The shallow trays can be packed into a master carton.

Quicker, cheaper packaging methods can be worked out, e.g. with bunches. It is not necessary to transport stems in vials of water. Carton liners of plastic are essential to maintain quality.

Messages for importers and wholesalers
Recut stems and place into a germicide, commercial postharvest solution, or flower food. Cool the flowers.

Messages for retailers and customers
Recut stems and place into a germicide or flower food.

Vase life of freshly cut flowers
They have a vase life of approximately 10 days.
BORONIA

Botanical name: *Boronia heterophylla*, *Boronia* species.
Common name: Boronia.
There are several varieties.

Harvesting
Harvest when 50% or more individual flowers are open, as buds don’t open after harvest. Place in water, germicide, hydrating solution or commercial solution in the field.

Ethylene sensitivity and anti-ethylene treatments
*Boronia heterophylla* is moderately sensitive to ethylene. *B. ‘Lipstick’* may be sensitive. *B. clavata* and *B. muelleri* ‘Sunset Serenade’ are not. Ethylene will cause flower wilting and drop, and leaf drop. STS treatment increased life of *B. heterophylla* and *B. ‘Lipstick’. STS and 1-MCP protected *B. heterophylla* from effects of external ethylene.

Postharvest solutions
Hold the flowers in a germicide, hydrating solution or commercial solution for 8 to 16 hours after harvest to increase life. This could follow short STS treatments or be used during 1-MCP treatment.

Cooling
2°C to 4°C. Cooling soon after harvest improves quality and life.

Grading and bunching
Flowers are usually sold 10 stems to a bunch. Stems of red *Boronia* are usually 40 to 60cm and bunches are 250 to 300g. Stems of brown and yellow *Boronia* are usually 25 to 40cm and bunches are 150g.

Signs of bad quality
Yellow foliage, signs of leaf and petal drop, faded flowers and rust.

Pest and disease control
*Botrytis* is found on some flowers of *Boronia*, and may be due to the cool damp growing conditions that they prefer. May be worth treating for *Botrytis* in the field or postharvest. Field sprays of registered fungicides, may need to be used fortnightly from bud formation to harvest, particularly in wet weather. Use postharvest dips in registered fungicides where this use is registered and approved.
Storage

*Boronia heterophylla* has a very short vase life after storage e.g. 3 to 4 days.

Packaging

Stems need to be packaged to prevent water loss. Wrap stems in wet newspaper, mist the flowers, or use plastic carton liners or sleeves.

Messages for importers and wholesalers

Recut stems and place into a germicide, commercial postharvest solution, or flower food. Cool the flowers.

Messages for retailers and customers

Recut stems and place into a germicide or flower food.

Other important considerations

Handle the stems carefully as the flowers drop easily.

Wilted stems can apparently be revived, by putting the whole stem under water for 2 to 3 hours.

*America* will not currently accept *Boronia* or other flowers from the Rutaceae family.

Vase life of freshly cut flowers

The vase life of flowers that have been handled well (with water, cooling and quick handling) can be 7 to 11 days. If the flowers are not handled well, vase life may be as short as 3 to 4 days.
CAUSTIS

Botanical name: *Caustis blakei*.
Common name: Koala fern.

Harvesting
*Caustis* is currently bush-picked but it is hoped that it can
be cultivated soon.

Ethylene sensitivity
Unknown.

Postharvest solutions
Use a germicide or commercial solution.

Cooling
2°C to 4°C.

Grading and bunching
Stems are usually sold in 10 stem bunches. Stems are
usually 50cm long or longer.

Storage
Can be stored dry at 0°C for 4 weeks, and still have a good
vase life of 10 days.

Messages for importers and wholesalers
Recut stems and place into a germicide, commercial
postharvest solution, or flower food. Cool the flowers.

Messages for retailers and customers
Recut stems and place into a germicide or flower food.

Vase life of freshly cut flowers
*Caustis* has a good vase life of 16 to 19 days.
CERATOPETALUM

Botanical name: *Ceratopetalum gummiferum.*
Common name: NSW Christmas bush, Festival bush.
There are several varieties.

**Harvesting**
Harvest when color of the sepals becomes deep red and only 1 to 5% of the white flowers remain. The time of maximum color can be judged with experience. Avoid picking in the heat of the day (above 28°C to 30°C). Professionals place stems in water and postharvest solution within 3 minutes of picking and put into a cold room within 45 minutes.

**Ethylene sensitivity**
*Ceratopetalum* may be sensitive. In one experiment 1-MCP protected against flower and sepal drop caused by ethylene. Anti-ethylene treatments are not used commercially.

**Postharvest solutions**
Use water containing a germicide or commercial solution. A mixture of chlorine (0.1g/l or 1g/10l) and citric acid (0.2g/l or 2g/10l) is used by some growers.

**Cooling**
6°C to 8°C. Cool for a minimum of 4 hours before processing. Lower temperatures cause damage.

**Grading and bunching**
Stems are usually sold in 3, 5 or 10 stem bunches. Stems are graded to 40, 50, 60, 70 or 90cm long. Leaves are stripped from the lower 10 to 20cm of stem. Stems are graded by the amount of red color per stem length.

**Signs of bad quality**
Darkening of red sepals. Sepal drop.

**Pest and disease control**
Use postharvest dips in registered insecticides and/or fungicides where this use is registered and approved. Pack when nearly dry.

**Storage**
Dry storage for 3 to 4 weeks at 5°C is possible. Postharvest fungicide is essential.

**Packaging**
Use a plastic carton liner or sleeves to prevent drying out.
Messages for importers and wholesalers
Recut stems and place into a germicide, commercial postharvest solution, or flower food. Cool the flowers.

Messages for retailers and customers
Recut stems and place into a germicide or flower food.

Other important considerations
It is essential that plants are sheltered from hot dry winds.

Vase life of freshly cut flowers
Usually 7 to 14 days.
CHAMELAUCIUM

Botanical name: *Chamelaucium uncinatum*, *Chamelaucium* species.
Common name: Geraldton wax, Waxflower, Budwax, Pearl Bud.
There are many varieties and hybrids.

**Harvesting**
Stems are picked in bud for "budwax", when the buds are showing color and are approximately 5 mm across. Flowering stems are picked when 25 to 50% of the flowers are open. Some varieties, such as *C. uncinatum* and *C. megalopetalum* hybrids are picked with 60 to 80% flowers open. See Beal et al. (1998) for photos of harvest stages.

**Ethylene sensitivity and anti-ethylene treatment**
Most *Chamelaucium* varieties are very ethylene sensitive and drop individual flowers after contact.
STS and 1-MCP are both effective in reducing flower drop and protecting against ethylene.

**Postharvest solutions**
If a solution other than STS is needed, use a germicide or commercial solution.

**Cooling**
2°C to 4°C. Cool as soon as possible after harvest. Forced-air cooling can be used after packing.

**Grading and bunching**
Flowers sold either 10 stems to bunch or weight of 400g. Stem length should be at least 60cm, except for those species that the market will accept shorter. Stems should be less that 7mm across. Leaves should be removed from the lower 20cm on the stem.

**Signs of bad quality**
Damaged flowers e.g. flower or petal drop, shrivelled buds, or *Botrytis* (brown marks on petals).
Damaged leaves or stems e.g. tip burn, gall wasp nodules, wilted tips, yellowing, bent stems, disease damage, or excessive tip growth beyond flowers.

**Pest and disease control**
Insects and *Botrytis* fungus, which causes flower drop, need to be controlled in the field. Use postharvest dips in registered insecticides and/or fungicides where this use is registered and approved. Dry the flowers on a bench, or while they are standing in water, before packing.
Other fungi, *Pleospora* (forms of *Alternaria* and *Stemphylium*) have been found on flowers arriving in USA. These need to be controlled in the field.

Keeping flowers cold and dry reduces fungal growth.

**Storage**

Short term storage (e.g. 2 weeks) is possible if the flowers are treated with fungicide to stop *Botrytis* growth and if the storage temperature is 1°C.

**Packaging**

*Chamelaucium* is usually packed tightly into fibreboard cartons. It is best to avoid plastic carton liners or sleeves, at least around the open flowers, as they will increase humidity and *Botrytis* growth. Forced-air cooling holes in the cartons should be left open to reduce humidity, ethylene build up, *Botrytis* growth and flower drop.

**Messages for importers and wholesalers**

Recut stems and place into a germicide, commercial postharvest solution, or flower food. Cool the flowers.

**Messages for retailers and customers**

Recut stems and place into a germicide or flower food.

**Other important considerations**

The labor needed for picking, treating and packing is approximately 2 people per ha during the main harvest season (Carson 2000).

Flowers from cultivated plants can have up to double the vase life of bush picked flowers.

Wilting of soft tip growth is a problem that can be solved by reduced watering, early harvest, good cooling and water uptake, or avoided by cutting the tips off (if the market will accept that).

The flowers can be easily damaged, which will cause the petals to drop off.

**Postharvest vase life**

The typical vase life of a fresh, good quality flower is 10 days, but after export it is closer to 7 days.

There are large differences in vase life between species and varieties. In one experiment ‘Newmarracarra’ had a 5 day life, ‘CWA Pink’ 7 days, ‘Purple Pride’ 11 days and ‘Mullering Brook’ 12 days.
CONOSPERMUM

Botanical name: Conospermum incurvum, C. eatoniae
Conospermum species.
Common name: Smokebush.

Harvesting
Harvest when first individual flowers appear open. Place stems into water in the field, as they dry out easily.

Ethylene sensitivity
Not sensitive.

Postharvest solutions
Blue species (C. eatoniae and C. caeruleum) must have their stems placed in water, preferably containing a germicide or commercial postharvest solution, after picking).

Cooling
Cool to 2°C to 4°C before shipment or export.

Grading and bunching
Bunches of 5 are common for C. eatoniae, 10 for C. caerulea and 10 to 15 for other species. Stems are usually 50 cm or longer. C. eatoniae are best packed in perforated sleeves to prevent tangling.

Messages for importers and wholesalers
Recut stems and place into a germicide, commercial postharvest solution, or flower food. Cool the flowers.

Messages for retailers and customers
Recut stems and place into a germicide or flower food.

Source:
Seaton (1999a).
CORYNANTHERA

Botanical name: Corynanthera flava.
Common name: Golden cascade.

Harvesting
Flowers currently only picked from managed bush stands on private property, under licence from CALM (WA). CALM recommends that no more than 20% of available flowering stems are cut in any one season and that leaves are retained below the cut. Picking is banned on crown land. Stems should be placed in clean water after picking.

Ethylene sensitivity
Not sensitive

Postharvest solutions
No special solutions are necessary, but a germicide in the water is advisable.

Cooling
2°C to 4°C.

Grading and bunching
Flowers usually sold 15 to 30 stems to a bunch. Stems are usually 60cm to 80cm long.

Messages for importers and wholesalers
Recut stems and place into a germicide, commercial postharvest solution, or flower food. Cool the flowers.

Messages for retailers and customers
Recut stems and place into a germicide or flower food.

Source:
CROWEA

Botanical name: Crowea exalata, C. saligna.  
Common name: Crowea.  
There are a few varieties.

Harvesting  
Harvest when the flowers are in late bud stage or half open.

Ethylene sensitivity and anti-ethylene treatments  
Crowea exalata may be ethylene sensitive, as the use of STS will increase vase life by reducing flower drop. The sensitivity of the other species and varieties is unknown.

Postharvest solutions  
Place in water containing a germicide or commercial postharvest solution. The sugar in commercial solutions may improve flower opening.

Cooling  
2°C to 4°C.

Grading and bunching  
Flowers usually sold 10 stems to a bunch. Stems are usually 30cm long or longer.

Messages for importers and wholesalers  
Recut stems and place into a germicide, commercial postharvest solution, or flower food. Cool the flowers.

Messages for retailers and consumers  
Recut stems and place into a germicide or flower food.
**ERIOSTEMON**

**Botanical name:** *Eriostemon australasius,* *Philotheca myoporoides,* *Philotheca* species.

**Common name:** Austral eriostemon, Pink eriostemon, Waxflower, Eastern wax.

**Note:** *Philotheca* is the new name for some *Eriostemon.*

**Harvesting**
Harvest as individual flowers are just starting to open, and buds are fully colored.

**Ethylene sensitivity**
Unknown.

**Postharvest solutions**
Use a germicide or commercial solution.

**Cooling**
2°C to 4°C.

**Grading and bunching**
Flowers are usually sold 5 stems to a bunch. Stems are usually 50cm long or longer.

**Signs of bad quality**
Shrivelled petals and flowers. Yellow foliage. Petal drop.

**Messages for importers and wholesalers**
Recut stems and place into a germicide, commercial postharvest solution, or flower food. Cool the flowers.

**Messages for retailers and customers**
Recut stems and place into a germicide or flower food.

**Other important considerations**
Flower drop is sometimes a problem. This may be caused by picking when the flowers are too mature or packed wet, or by *Botrytis* and ethylene. Therefore, using a fungicide dip or anti-ethylene treatment may be worthwhile.
EUCALYPTUS

Foliage
Botanical name: *Eucalyptus gunnii*, *E. crenulata*, *Eucalyptus* species.
Common name: Eucalyptus, Gum.
There are several species used for cut foliage.

Flowers and buds
Botanical name: *Eucalyptus tetragona*, *E. forrestiana*, *Eucalyptus* species.
Common name: Eucalyptus, Gum.
There are a number of species used for buds and flowers.

Harvesting
Harvest for buds and nuts when they are at the appropriate stage of development. When harvesting for use as a cut flower, harvest when the cap is starting to lift from the flowers.

Ethylene sensitivity
The sensitivity of flowers is not clear, but one report states that ethylene caused stamens to drop.
The foliage of *E. crenulata* and *E. gunnii* is not ethylene sensitive.

Postharvest solutions
Use a germicide. Holding stems with buds in germicide for 2 to 4 hours before cooling and packing is good for many species.
The caps on buds of some species (e.g. *E. youngiana*) open if they are left in water too long (more than 4 to 6 hours). Species with small buds can be left in water for 6 to 8 hours before cooling and packing.

Cooling
2°C to 4°C.

Grading and bunching
Foliage is usually sold 10 stems to a bunch. Stems are usually 60cm long or longer. The requirements for buds, nuts and flowers will vary between species and should be agreed between buyer and seller.

Signs of bad quality
Insect damage, poor leaf color, and wilting of soft tips.

Pest and disease control
Field control is essential. Insects in gum nuts may be hard to kill.
Storage
Foliage can be stored cold and dry for up to 30 days without affecting vase life.

Packaging
Stems should be dry before packing, and carton liners around the long sides of the box are often used. Stems of some species can be placed in vials of water/germicide for marketing.

Messages for importers and wholesalers
Recut stems and place into a germicide, commercial postharvest solution, or flower food. Cool the flowers.

Messages for retailers and customers
Recut stems and place into a germicide or flower food.

Other important considerations
The labor needed for picking, treating and packing Eucalyptus (foliage or flowers) is approximately 2 people per 4ha during the harvest season (year-round for foliage) (Carson 2000).

Soft tips on spring growth can be a problem. Reduced irrigation may prevent this.

Vase life of freshly cut flowers
Foliage has a life of at least 7 to 14 days, and flowers a life of 8 to 14 days. Buds have a life of 14 to 21 days.
GELEZNOWIA

Botanical name: Geleznowia verrucosa.
Common name: Yellow bells.

Harvesting
Pick just before the first (top) flower on a stem opens. Pick before any red coloring appears.

Ethylene sensitivity
Not sensitive.

Postharvest solutions
Use a germicide or commercial solution. Overnight treatments with germicide, strong citric acid (2g/l) or Chrysal CVB® (17 hours, 1°C) slightly increased vase life compared with using water only.

Cooling
2°C to 4°C.

Grading and bunching
Flowers are usually sold 10 stems to a bunch. Stems are usually 30cm long or longer.

Signs of bad quality
Dry bracts or leaves, red coloring on bracts of sepals, swelling, or fruit development at the base of the flower.

Messages for importers and wholesalers
Recut stems and place into a germicide, commercial postharvest solution, or flower food. Cool the flowers.

Messages for retailers and customers
Recut stems and place into a germicide or flower food.

Other important considerations

Vase life of freshly cut flowers
Long multi-headed stems have a vase life of 5 to 10 days. Export reduces vase life by 2 days.

Source:
Grevillea

**Botanical name:** Grevillea whiteana, Grevillea species.
**Common name:** Grevillea, Spiderman (an internationally known variety).
There are many varieties and hybrids.

**Harvesting**
Pick when between 10 and 70% of the individual flowers on the head have the pin-like styles looping out from the head. See Beal et al (1995), Joyce and Beal (1999) and Section 2.3 for photos of harvest stages.

Pick into water, germicide, hydrating solution or commercial solution to avoid drying.

**Ethylene sensitivity and anti-ethylene treatments**
Most are sensitive, although G. hookeriana is not. Ethylene causes a lot of flower and bud drop. Flower drop caused by ethylene can be reduced by pretreatment with an STS pulse or 1-MCP.

**Postharvest solutions**
Use a hydrating solution or commercial solution. Allow the stems to take up solution for 8 hours at 10°C to 20°C before cooling and packing.

**Cooling**
2°C to 4°C.

**Grading and bunching**
Flowers are usually sold 10 stems to a bunch. Stems are usually 50cm long or longer. When bunching flowers, take care that the flowers do not interlock, as they can be damaged when separating them. They can be sleeved, or rolled in paper, to prevent inter-locking.

**Signs of bad quality**
Over-mature heads, damaged flowers, dropping flower parts, uneven arrangement of flowers on head, multi-headed stems.

**Pest and disease control**
Don’t dip the flower as the styles are easily damaged.

**Storage**
Flowers of G. ‘Sylvia’ lose a third of their vase life (down to 6 days) after being stored dry for 12 days at 0°C.
Packaging
Using sleeves or paper may help protect the flower heads. Otherwise, styles can interlock and break.

Messages for importers and wholesalers
Recut and place into a vase solution containing a commercial flower food. Cool flowers.

Messages for retailers and customers
Recut stems. A vase solution containing a commercial flower food with sugar will provide a better vase life.

Other important considerations
Grow varieties that have a long vase life. See Beal et al (1996) or Joyce and Beal (1999) for a list of grevilleas with more than 6 days vase life.

Some people have an allergic skin reaction to flowering stems of Grevillea.

Vase life of freshly cut flowers
6 to 10 days depending on the variety or hybrid.
IXODIA

Botanical name: *Ixodia achillaeoides* sub-species *alata.*
Common name: South Australian daisy, Hills daisy.
These are grown for drying and for fresh flowers. The following advice is mainly for fresh flowers.

**Harvesting**
Harvest when flower heads are fully open.

They are too mature when the centre of the flower head is raised and the smaller, inner flowers have changed to grey or brown.

Either pick by hand and bunch in the field or cut the whole bush (e.g. with hedge-cutters) and sort and bunch in the shed.

When picking by hand, snap the stems between thumb and forefingers. Wear gloves, as sticky gums build up and blacken hands.

**Ethylene sensitivity**
Not sensitive.

**Postharvest solutions**
The stems should be placed in a solution for several hours or overnight in the cold room. Use a germicidal or commercial postharvest solution.

**Cooling**
2°C to 4°C.

**Grading and bunching**
Flowers are usually sold 10 stems to a bunch or by weight e.g. 200g. Stems are usually 40 to 50cm long for fresh flowers.

**Pest and disease control**
*Botrytis* can infect the flowers before harvest, damaging the flowers and causing them to discolored. This should be controlled in the field or the stems will be unable to be sold.

**Storage**
Stems can be stored dry at 0°C to 2°C for up to 2 weeks. Storage in water can cause stem blackening in some varieties.

**Packaging**
Some flower heads will close when they are packed, but they will reopen when unpacked.

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Messages for importers and wholesalers
Recut stems and place into a germicide, commercial postharvest solution, or flower food. Cool the flowers. Flower heads will temporarily close if they are wet or in high humidity (e.g. in cartons), but they will open once they are taken out of the carton.

Messages for retailers and customers
Recut stems and place into a germicide or flower food.

Other important considerations
Flowers will temporarily close if wet or in high humidity. Leaves and stems go black when they are damaged.

Vase life of freshly cut flowers
Vase life is between 10 to 14 days.

Source:
Barth 1998.
LEPTOSPERMUM

Botanical name: *Leptospermum* species.
Common name: Tea tree.
There are many species, varieties and hybrids.

**Harvesting**
Harvest when the buds are fully colored and a quarter to half the individual flowers are open. Where possible, pick into water as *Leptospermum* are prone to drying out.

**Ethylene sensitivity and anti-ethylene treatments**
*Leptospermum scoparium* and its hybrids are sensitive to ethylene. *L. rotundifolium*, *L. petersonii*, and some forms of *L. morrisonii* are also sensitive. Other species and forms are not sensitive (e.g. forms of *L. morrisonii*). Ethylene causes buds, petals and individual flowers to drop, or petals to dry out.

STS treatment reduced flower drop in *L. rotundifolium*. STS and 1-MCP protect several species against the effects of external ethylene (*L. rotundifolium*, *L. scoparium hybrids and L. petersonii*).

**Postharvest solutions**
Use a hydrating solution or a commercial solution. Holding stems in deep water (even 20cm) improves water uptake in some species.

**Cooling**
2°C to 4°C.

**Grading and bunching**
Flowers are usually sold 5 stems to a bunch or by weight (e.g. 400g). Stems are usually 50cm long or longer.

**Signs of bad quality**
Tip wilt, petal drop.

**Pest and disease control**
*Botrytis* infection occurs in some *Leptospermum* flowers and this may lead to flower and petal drop as in *Chamelaucium*. In USA, petal drop is reduced by field fungicide treatments.

**Packaging**
Minimise drying out by using plastic carton liners, with an inner paper liner.

**Messages for importers and wholesalers**
Recut stems and place into a germicide, commercial postharvest solution, or flower food. Cool the flowers.
Messages for retailers and customers
Recut stems and place into a germicide or flower food.

Other important considerations
There are large differences in the vase life of different species and varieties. It is important to grow those that have a good vase life. See Slater et al. (2001) for the vase life of species and hybrids.

*L. scoparium* and its hybrids are likely to drop petals and dry out. Export markets will not accept them from Australia for this reason.

Soft tip growth wilts badly.

A dip in benzyladenine (0.05 g/l or 0.5 g/10 l) reduced petal drop in *L. scoparium* hybrids.

Vase life of freshly cut flowers
3 to 12 days depending on the species. *L. scoparium* hybrids often have only a few days vase life.

Some species had adequate life after export (*L. rotundifolium*) but others had a very short life (*L. grandifolium, L. morrisonii* and *L. obovatum*).
LEUCADENDRON

Botanical name: *Leucadendron* species.
Common name: Leucadendron. There are many species and varieties used. Male and female flowers are also used and are found on different plants.

**Harvesting**
Harvest when the leaves and bracts are coloring and before the flowers open. Tips must be hardened off (not soft) and for large blooms, tips must be leathery to touch. Some species (e.g. 'Inca Gold') are picked as multi-headed stems for some markets. Some species are used for foliage, including stems without flowers or cones.

**Ethylene sensitivity**
Not sensitive.

**Postharvest solutions**
Use a germicide or commercial solution. Some of the hardier *Leucadendron* could be handled dry as long as they are processed quickly and cooled before transport.

**Cooling**
2°C to 4°C.

**Grading and bunching**
Flowers are usually sold in bunches of 10. Stems are usually 40cm or longer. For multi-headed stems, bunch size is more important than stem number. The bottom one-third, or at least 20cm, of leaves should be stripped off the stem.

**Signs of bad quality**
Insect damage, poor flower color, yellowing leaves, black styles.

**Pest and disease control**
Male *L. discolor* can be affected by *Botrytis* if picked and stored wet.

**Storage**
Cold storage for 6 weeks at 1°C (dry) is possible with little loss of vase life (e.g. ‘Silvan Red’, ‘Safari Sunset’). Drying out during storage can be reduced by a postharvest treatment of 200g/l sugar plus germicide for 24 hours at 2°C to 4°C.

**Packaging**
Pack firmly in cartons lined with paper. Don’t pack wet.
Messages for importers and wholesalers
Recut stems and place into a germicide, commercial postharvest solution, or flower food. Cool the flowers.

Messages for retailers and customers
Recut stems and place into a germicide or flower food.

Other important considerations
Some export markets will not accept fresh, mature cones because they are considered to be fruit that might contain seeds or fruit-flies. Check with your exporter.

Vase life of freshly cut flowers
14 days or longer.
LEUCOSPERMUM

Botanical name: *Leucospermum cordifolium*, *Leucospermum* species.
Common name: Pincushions, Firewheel, Cordifoliums. There are numerous varieties and hybrids.

**Harvesting**
Harvest when about 25% of the flowers on the head have straight styles and the rest are loosening (“looping”).

**Ethylene sensitivity**
Probably not sensitive.

**Postharvest solutions**
Use a germicide or commercial solution.

**Cooling**
2°C to 4°C.

**Grading and bunching**
Flowers are sold either as singles or 5 stems to a bunch. Stems are usually 40cm long or longer. Flower heads should be near perfect, and straight or less than 45° to the stem. Flower heads should be intact and a good size and colored. Stems should be straight and foliage without damage. Leaves are stripped from the bottom third of the stem, or a minimum of 20cm, depending on the customer.

**Signs of bad quality**
Spotted, diseased, yellow or damaged leaves. Broken styles, heads old and discolored.

**Pest and disease control**
Dipping may damage styles.

**Storage**
Can be stored for 3 weeks and still have a vase life of 1 week, provided there is no fungal infection on the flowers.

**Packaging**
Single stems are usually packed in a single layer, or with paper between layers. Cartons may have plastic liners. For the domestic market, bunches are sleeved and packed firmly, but not tightly, in multiple layers.

**Messages for importers and wholesalers**
Recut stems and place into a germicide, commercial postharvest solution, or flower food. Cool the flowers.

**Messages for retailers and customers**
Recut stems and place into a germicide or flower food.
Other important considerations
Some leucospermums have dry leaves following dry transport. These stems can be rehydrated by immersing the whole stem and flower in warm water (40°C) for 30 minutes. In less severe cases, recutting stems and placing them in germicide or commercial solutions will rehydrate the flowers.

Vase life of freshly cut flowers
14 days or longer.
OZOTHAMNUS

Botanical name: Ozothamnus diosmifolius.
Common name: Rice flower.
There are several varieties.
Note: Ozothamnus is the new name for some Helichrysum.

Harvesting
Harvest when 50% of the small buds (or grains) have reached full size (usually match-head size) and are plump (tulip stage) but have not broken open at the top. At this stage, the overall flower head has reached its maximum size (e.g. 5 to 10cm diameter). Do not pick after 10% of the buds have broken open at the top. These harvest stages are shown in Beal et al. (2001). If they are picked too early, the head will wilt. Over-mature heads will fall apart.

There is only a 1 to 10 day window for harvesting in hot climates, but 15 to 25 days in cooler climates. A once-over harvest can be done when all the stems mature at once. Machines such as mechanical pruners can be used for this. When flowers mature slowly, individual stems can be cut at the right maturity.

Ethylene sensitivity and anti-ethylene treatments
Rice flower is slightly sensitive to ethylene, especially the ethylene they produce themselves. STS treatment reduces leaf blackening and drop, and increases the vase life, at least in some forms.

Postharvest solutions
Rice flower appears to require water or rapid cooling and may benefit from both. They can probably be handled dry as long as they are given forced-air cooling within 3 hours of harvest. If they are held in water, add a germicide or commercial solution. Overnight treatment (16 hours at 2°C to 4°C with strong citric acid (2g/l) or Agral® (0.1ml/l plus aluminium sulphate or quaternary ammonium germicide at 0.2g a.i. increased vase life.

Cooling
2°C to 4°C. Cool to 2°C to 4°C within 3 hours of cutting. Cooling reduces leaf blackening.

Grading and bunching
Flowers are usually sold 5 stems to a bunch or by weight (e.g. 400g). Stems are usually 50cm long or longer.

Examples of grading standards are described in Beal et al. (2000).
Handle gently as rough handling will cause leaves and stems to go black.

**Signs of bad quality**
Crooked stems, yellow or dry leaves, shoots growing past the flower heads, wilting shoots below the flower head, brown fuzz on flower heads and blackened leaves.

**Pest and disease control**
Use postharvest dips in registered insecticides and/or fungicides where this use is registered and approved.

**Packaging**
Pack firmly in cartons to prevent movement and damage to the flower heads. If they are too firm, the stems become crushed and the stems will blacken.

**Messages for importers and wholesalers**
Recut stems and place into a germicide, commercial postharvest solution, or flower food. Cool the flowers.

**Messages for retailers and customers**
Recut stems and place into a germicide or flower food.

**Other important considerations**
Grow varieties that have a longer window of harvest than just a few days.

Leaf blackening is more likely if it is hot (greater than 25°C) or raining during harvest, if there are delays in cooling or if the flowers warm up during transport.

After hot dry weather, cut flowers drop leaves and flowers. Irrigation the night before picking may be worthwhile.

**Vase life of freshly cut flowers**
7 to 14 days.
PIMELEA

Botanical name: *Pimelea physodes*, *P. nivea*.
Common name: Qualup bells.
The following refers to *P. physodes* (Qualup bell).

**Harvesting**
Harvest when both pairs of bracts are slightly open.

**Ethylene sensitivity**
Unknown.

**Postharvest solutions**
Use a commercial solution or sugar solution (20g/l) plus germicide.

**Cooling**
Flowers benefit from forced-air cooling and being kept at 2°C to 4°C as much as possible.

**Packaging**
Pack flowers carefully in perforated sleeves, to prevent crushing the bracts.

**Messages for importers and wholesalers**
Recut stems and place into a germicide, commercial postharvest solution, or flower food. Cool the flowers.

**Messages for retailers and customers**
Recut stems and place into a germicide or flower food.

**Other important considerations**
*P. nivea* is grown for foliage.

**Vase life of freshly cut flowers**
Cut stems have a vase life of 9 days when harvested from cultivated plants.

**Source:**
Seaton (1999b)
PROTEA

Botanical name: *Protea* species.  
Common name: Protea.  
There are numerous species, varieties and hybrids.  

Harvesting  
Harvest when the flower bracts (leaf-like structure, usually below flower head and sometimes brightly colored) are starting to open. The stage of opening will depend on the species, as some continue to open during transport. See AFPGA 2000 for detailed recommendations for individual species.

Don’t pick when leaves are wet. If this is unavoidable, make sure they are dry before packing.

Place in water as soon after harvest as possible (maximum 1 hour).

Ethylene sensitivity  
Not sensitive.

Postharvest solutions  
Use a germicide or commercial solution.

Leaf blackening  
The rapid blackening of leaves is a major postharvest problem with a number of proteas such as: *P. compacta, P. cynaroides, P. eximia, P. lepidocarpodendron, P. longiflora, P. macrocephala, P. magnifica, P. neriifolia, P. repens, P. ‘Pink Ice’, and P. ‘Fire and Ice’.

To reduce leaf blackening:

Grow species and varieties that are not prone to leaf blackening.

In hot weather, water plants the night before picking.

Cool cut flowers and avoid temperature changes.

Keep stems in a germicide or commercial solution.

Provide light in the packing shed and cool room - like bright room or office lighting.

Keep the leaves dry. Do not bunch when wet. If necessary, place stems in water and dry the flowers with fans before bunching, but take care to not let flowers dry too much.

Move flowers quickly on to customers.
Cooling
2°C to 4°C.

Grading and bunching
Flowers are sold as single stems or 5 stems to a bunch. Stems are usually 30cm long or longer. Flower heads should be intact and a good size and colored for the species and variety. Stems should be straight and foliage should only have minimal damage. Leaves should be stripped carefully off the lower 20cm of stem, or about a third of the length, depending on the buyer. Keep benches clean so the sticky flowers don't pick up dirt.

Signs of bad quality
Over mature flower heads, damaged leaves, spotted yellow or black leaves, dull flower color.

Pest and disease control
Scale, earwigs, spiders and bees can be a problem. Field control is essential. Use insecticide fumigation, not dips. Check flower heads for bees caught in the flowers.

Storage
Some proteas can be cold stored but they lose quality, freshness and color. P. 'Pink Ice' was stored for 3 weeks at 1°C and still had a vase life of 9 to 11 days. P. cynaroides was stored for 3 weeks and had a life of 6 days.

Packaging
Pack only dry, cold flowers. Dry stems. Line cartons with a plastic liner and an inner layer of paper.

Messages for importers and wholesalers
Recut stems and place into a germicide, commercial postharvest solution, or flower food. Cool the flowers.

Messages for retailers and customers
Recut stems and place into a germicide or flower food.

Other important considerations
The labor needed for picking, treating and packing is approximately 2 people per 4ha during the harvest season (Carson 2000). Recent research on leaf blackening has shown that holding stems of P. 'Sylvia' continuously in 25 g/l glucose sugar markedly delayed blackening. Short treatment with higher concentrations may be effective (Stephens et al. 2001). Other research showed that fumigation with ethanol vapor delayed blackening (Cannon and McConchie 2001).

Vase life of freshly cut flowers
7 to 14 days.
SERRURIA

Botanical name: *Serruria florida.*
Common name: Serruria, Blushing Bride, Superb Blush.

**Harvesting**  
Harvest when the first flower head on stem is fully open.

**Ethylene sensitivity**  
Unknown.

**Postharvest solutions**  
Use a germicide or commercial solution.

**Cooling**  
2°C to 4°C.

**Grading and bunching**  
Flowers are usually sold 10 stems to a bunch. Stems are usually 30cm long or longer.

**Storage**  
There is some evidence that they can be stored for up to 4 weeks at 1°C, but there will be some loss of quality.

**Messages for importers and wholesalers**  
Recut stems and place into a germicide, commercial postharvest solution, or flower food. Cool the flowers.

**Messages for retailers and customers**  
Recut stems and place into a germicide or flower food.

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Section 4: Specific postharvest treatments for individual crops
SWAINSONA

Botanical name: *Swainsona formosa*
Common name: Sturt Desert Pea
Note: *Swainsona* is the new name for some *Clianthus*.

Harvesting
Can be cut as individual flower heads, or as runners with several flower heads on them.

Harvest as buds are opening, as immature buds do not open after harvest.

Pick into water and germicide. Don’t use chlorine germicide if they’ll be treated with STS. Alternatively use a commercial postharvest solution.

The flowers should be sleeved and covered with a plastic sheet to stop drying out.

Ethylene sensitivity and anti-ethylene treatments
Cut flower heads are ethylene sensitive, and vase life can be increased by treatment with STS. Ethylene causes the flowers to drop.

The best anti-ethylene treatments are probably 1-MCP which can be combined with sugar treatments (see below), or a short STS treatment, which can be followed by sugar treatment.

Postharvest solutions
Use water containing a germicide or commercial solution. There are benefits from supplying sugar in postharvest solutions e.g. overnight in the cold room. Use either:

- Commercial solution

- Sucrose (20g/l for runner or 40g/l for flower heads) plus 0.1g/l stabilised pool chlorine and 0.2g/l citric acid.

Cooling
4°C or above.

Storage
Flowers can be kept for 4 days at 4°C, provided they are in vials containing water. They cannot be stored dry.

Packaging
Flower heads are fragile and need physical support and protection from drying out. Stems can be placed into vials to provide liquid, and supported with a cardboard frame. Alternatively, flower heads could be sleeved and packed in
Postharvest Handling of Australian Flowers

Section 4: Specific postharvest treatments for individual crops

single layer trays.

Messages for importers and wholesalers
Recut stems and place into a germicide, commercial postharvest solution, or flower food. Cool the flowers.

Messages for retailers and customers
Recut stems and place into a germicide or flower food.

Other important considerations
Hardened runners should be produced to prevent wilting and drying out.

Leaves and growing tips can be removed from runners to increase vase life.

Sometime pollen falls onto the dark petals and looks unattractive.

Vase life of freshly cut flowers
Vase life varies with variety and growing conditions e.g. 8 to 13 days, and longer with STS and sugar treatment.

Source:
Barth 1990.
TELOPEA

Botanical name: *Telopea speciosissima*. Telopea species.
Common name: Waratah.
There are numerous varieties and hybrids.

**Harvesting**
Harvest once the individual flowers start to open i.e. when 5 to 10% of styles (pins) are sticking out.

**Ethylene sensitivity and anti-ethylene treatments**
The flowers are sensitive to ethylene, which causes the flower tube to come away, turn blue and dry out. STS and 1-MCP protect against ethylene but do not increase vase life if the flowers are not exposed to ethylene.

**Postharvest solutions**
Waratahs are sensitive to drying out and this can cause individual flower drop, blueing and shortened vase life. They should be placed in water and germicide or a commercial solution as soon as possible after harvest. Holding flower stems in deep water (e.g. 20cm) improves water uptake after harvest.

**Cooling**
2°C to 4°C.

**Grading and bunching**
Flowers are sold as single stems or 5 stems to a bunch. Stems are usually 50cm long or longer. Handle the flowers carefully to avoid damage, especially as the styles can be easily broken.

**Signs of bad quality**
Browning of the bracts (leaf-like structure usually below flower head) can be a problem. Blueing and flower drop.

**Pest and disease control**
Registered insecticide treatments are needed for export flowers. If flowers are to be held or transported for more than a couple of days, *Botrytis* growth may be a problem, so field sprays, rapid cooling and postharvest fungicide dips (where this is registered and approved) may be needed.

**Storage**
Waratahs can be stored dry at 1°C for 3 weeks with little effect on the vase life. Fungicide treatment may be necessary (see pest and disease control).
Packaging
Sleeves or carton liners can be used to protect the flowers and prevent drying out.

Messages for importers and wholesalers
Recut stems and place into a germicide, commercial postharvest solution, or flower food. Cool the flowers.

Messages for retailers and customers
Recut stems and place into a germicide or flower food.

Vase life of freshly cut flowers
Usually 7 to 14 days. Export can markedly reduce vase life, particularly if the flowers are warm or in transit for a long time.
THRYPTOMENE

Botanical name: *Thryptomene calycina*, *Thryptomene* species.
Common name: Thryptomene, Grampians thryptomene, Calycina.
There are several species and varieties. The following refers to *T. calycina*.

**Harvesting**
Harvest with 20 to 50% of the individual flowers open.
Don’t harvest after the first flowers start to change colored to dark pink as they will drop rapidly.

**Ethylene sensitivity and anti-ethylene treatments**
*Thryptomene* is sensitive to ethylene, which causes flower drop under high humidity, such as in cartons.
STS and 1-MCP protect against flower drop caused by ethylene.

**Postharvest solutions**
Use a hydrating solution or commercial solution. In stems with less than 25% flowers open, an overnight treatment with 10 g/l sugar (and germicide), or a commercial postharvest solution, will increase flower opening and vase life.
Spraying foliage with water can reduce drying out (but may increase *Botrytis* growth.

**Cooling**
2°C to 4°C.

**Grading and bunching**
Flowers are usually sold 10 stems to a bunch, or in bunches of 350 to 400g. Stems are usually 45 to 50cm long or longer.

**Signs of bad quality**
Avoid bunches with closed flowers, dry foliage, wilted tips, leaf discoloration or flower drop.

**Pest and disease control**
Infection with *Botrytis* may be a problem and cause flower drop. There may be benefits from using field sprays and/or fungicide dips effective against *Botrytis* (where this use is registered and approved).
Storage
*Thryptomene* can be stored for 3 to 4 weeks, dry at 1°C without loss of vase life, provided they are dipped in a fungicide to prevent *Botrytis*.

Messages for importers and wholesalers
Recut stems and place into a germicide, commercial postharvest solution, or flower food. Cool the flowers.

Messages for retailers and customers
Recut stems and place into a germicide or flower food.

Other important considerations
Late season stems often have soft tip growth, which is undesirable.

Some growers wet the foliage or cover the foliage with wet hessian to reduce water stress within the stems, rather than place the stems in water. Too much moisture on the flowers can create a problem with *Botrytis*. Recutting stems and placing them in hydrating solution may work as well.

Flower drop occurs at high humidity, for example in a carton, but stops when the flowers are transferred to room conditions. Flower drop is a problem, mainly when picked late, in full flower, with nectar.

Vase life of freshly cut flowers
7 to 14 days.
VERTICORDIA

Botanical name: Verticordia nitens, V. plumosa, Verticordia species.
Common name: Feather flowers.
A range of species is used.

Harvesting

Ethylene sensitivity and anti-ethylene treatments
Verticordia nitens is sensitive to ethylene and suffers flower drop, while V. chrysantha, V. densiflora and V. plumosa are not sensitive.

STS and 1-MCP treatments can protect against flower drop caused by ethylene in V. nitens.

Postharvest solutions
Recut stems and place into a germicide or flower food.

Cooling
2°C to 4°C.

Grading and bunching
Flowers are usually sold 10 stems to a bunch or by weight (e.g. 400g). Stems are usually 30cm long or longer.

Signs of bad quality
Flower drop, fungal infections on flowers, leaf damage.

Pest and disease control
Fungal infections on the flowers may be a problem, particularly during long transport. Use postharvest dips in registered insecticides and/or fungicides where this use is registered and approved.

Verticordias with fluffy flowers are damaged by dipping (e.g. V. serrata, V. insignis and V. monadelpha.

Storage
Verticordia monadelpha, V. plumosa and V. nitens were badly affected by 14 days storage, possibly due to fungal infections. V. grandiflora had a vase life of 10 days after 21 days storage.

Messages for importers and wholesalers
Recut stems and place into a germicide, commercial postharvest solution, or flower food. Cool the flowers.

Messages for retailers and customers
Recut stems and place into a germicide or flower food.
Vase life of freshly cut flowers
More than 14 to 24 days.
Other Crops

Following is an extensive list of flowers and foliage. They are all included in FECA’s book of Australian export flowers (FECA 2001). Although little is known about many of these flowers we hope that the reader will add notes to these pages as information becomes available.

**ADENANTHOS**
*Botanical name:* Adenanthos cygnorum, A. cuneatus, Adenanthos species.
*Common name:* Woolly bush.

Mainly used for foliage. Use a germicide or commercial postharvest solution.

**AGATHIS**
*Botanical name:* Agathis robusta.
*Common name:* Kauri pine.

Used for foliage. Use a germicide or commercial postharvest solution. Handle at 10°C to 15°C.

**AGONIS**
*Botanical name:* A. juniperina, A. linearifolia, A. parviceps and others.
*Common name:* West Australian tea tree.

Tea tree is usually sold to wholesalers in bunches of 10 to 15 stems (or 400g) that are made up in the field. Tea tree for fresh flowers requires immediate shading and placing in water (containing a germicide or commercial postharvest solution). It can be cooled with damp hessian or a mist spray in the field. Flowers should be delivered to a packing shed as soon as possible, at least within 4 to 5 hours. Cold storage may be required if transport is delayed.

**ALLOXYLON**
*Botanical name:* Alloxylon pinnatum.
*Common name:* Dorrigo waratah, tree waratah.

Flowers may be sensitive to ethylene. 1-MCP protected against the effects of ethylene, which caused flower drop. Use a germicide or commercial postharvest solution.
ASTARTEA
Botanical name: Astartea fascicularis, Astartea ‘Winter Pink’.
Common name: Astartea.

Harvest when half the flowers are open. Use a germicide or commercial postharvest solution.

ATHERTONIA
Botanical name: Athertonia diversifolia.
Common name: Athertonia.

Used for foliage. Use a germicide or commercial postharvest solution. Handle at 10°C to 15°C.

BEAUFORTIA
Botanical name: Beaufortia sparsa, Beaufortia species.
Common name: Swamp bottlebrush.

Harvest when half the individual flowers are open. Use a germicide or commercial postharvest solution to help the buds develop and open.

BRACTEANTHA, RHODANTHE
Botanical name: Bracteantha species, Rhodanthe species, Waitzia species.
Common name: Everlasting daisies.
Note: Bracteantha is the new name for some Helichrysum species. Rhodanthe is a new name for Helipterum.

Harvest when buds are showing strong-colored and are opening. At least one species, Rhodanthe chlorocephala rosea is sensitive to ethylene. The vase life of R. chlorocephala rosea was increased by flower food solutions.

CALLISTEMON
Botanical name: Callistemon species.
Common name: Bottlebrush.

Harvest when flowers are just starting to open. There is some evidence of ethylene sensitivity – individual flowers drop off. Use a germicide or commercial postharvest solution to help the flower open and last.
CALOMERIA
Botanical name: *Calomeria amaranthoides*.
Common name: Incense flower.

Use a germicide or commercial postharvest solution.

CALOTHAMNUS
Botanical name: *Calothamnus quadrifidus*.
Common name: One sided bottlebrush.

Harvest when half the individual flowers are open on a head. Use a germicide or commercial postharvest solution to help the buds develop and open.

CASSINIA
Botanical name: *Cassinia aureonitens*, *Cassinia* species.
Common name: Yellow Rice flower, Cassinia.

Harvest when the first small flower head is about to open. Flowers of *Cassinia adunca* are not sensitive to ethylene. Use a germicide or commercial postharvest solution. Treat similar to rice flower.

CRYPTANDRA
Botanical name: *Cryptandra scortechinii* also known as *Stenanthemum scortechinii*.
Common name: Cotton bush, Corroboree bush, Snow balls.

Use a germicide or commercial postharvest solution. Can survive without postharvest cooling. Vase life is up to 3 weeks. Flowers can also be used dried and dyed.

DARLINGIA
Botanical name: *Darlingia ferruginea*.
Common name: Darlingia, Brown Silky Oak.

Used for foliage. Use a germicide or commercial postharvest solution. Handle at 10°C to 15°C.
DARWINIA
Botanical name: *Darwinia* species.
Common name: Darwinia, Mountain bells.

Harvest when bells are just open. Use a germicide or commercial postharvest solution.

DASYPOGON
Botanical name: *Dasypogon* species.
Common name: Saviour grass.

Used for foliage. Use a germicide or commercial postharvest solution.

DICRANOPTERIS
Botanical name: *Dicranopteris linearis*.
Common name: Broad leaf umbrella fern.

Used for foliage. Use a germicide or commercial postharvest solution.

DODONEA
Botanical name: *Dodonea* species.
Common name: Hopbush.

*Dodonea sinualata acrodentata* has attractive ferny foliage and red fruit, but it dries out quickly in the vase. Vase life is improved by postharvest treatment with sugar (20g/l plus germicide) or commercial solution for 24 hours to 2°C to 4°C or 20°C.

DORYANTHES
Botanical name: *Doryanthes excelsa*.
Common name: Gymea lily.

Use a germicide or commercial postharvest solution. If stems can’t be held in water, keep the flowers cool.
DRYANDRA
Botanical name: *Dryandra formosa, D. polycephala, D. quercifolia.*
Common name: Dryandra, Bush rose.

Pick *D. formosa* and *D. quercifolia* when the first flower bracts have parted and the bud is swelling to a bulb shape, but before the stamens are visible. They are not ethylene sensitive. Use a germicide or commercial postharvest solution.

EREMOPHILA
Botanical name: *Eremophila* species.
Common name: Emu Bush.

Use a germicide or commercial postharvest solution.

ERICA
Botanical name: *Erica* species.
Common name: Erica, Heath, Heather.

Harvest *Erica* when the first individual flowers are open. Use a germicide or commercial postharvest solution. Flowers like to be misted. Flower drop is a problem with some ericas.

GAHNIA
Botanical name: *Gahnia* species.
Common name: Saw sedge.

Used for foliage. Use a germicide or commercial postharvest solution.

GLEICHENIA
Botanical name: *Gleichenia dicarpa.*
Common name: Gleichenia (fern).

Used for foliage. Use a germicide or commercial postharvest solution.

GUICHENOTIA
Botanical name: *Guichenotia macrantha, Guichenotia* species.
Common name: Guichenotia.

Use a germicide or commercial postharvest solution.
HAKEA
Botanical name: *Hakea francisiana, H. multilineata, Hakea* species.
Common name: Hakea, Pink Spikes.

Harvest with 25 to 50% of the styles (pins) of flowers looping, up to when the first flower’s style straightens up. Flowers are probably sensitive to ethylene. Handle as for *Grevillea*.

Use a germicide, hydrating solution or commercial solution.

HYPOCALYMMA
Botanical name: *Hypocalymma angustifolium, H. robustum, Hypocalymma* species.
Common name: Hypocalymma, Myrtle.

Harvest when a third to a half of the individual flowers are open. Flowers are probably not sensitive to ethylene. Use a germicide, hydrating solution or commercial solution.

ISOPOGON
Botanical name: *Isopogon latifolius, I. formosus, Isopogon* species.
Common name: Isopogon, Drumsticks, Coneflower.

Harvest when first ring (up to 30%) of individual flowers is opening. The flowers are probably not ethylene sensitive. Use a germicide or commercial postharvest solution.

KUNZEA
Botanical name: *Kunzea montana, K. parvifolia, Kunzea* species.
Common name: Kunzea.

Harvest when 30 to 50% of flower heads on the stem are open. Use a germicide or commercial postharvest solution.

LACHNOSTACHYS
Botanical name: *Lachnostachys verbascifolia, Lachnostachys* species.
Common name: Lambs tail.

Harvest when flowers are in bud or open. Flowers are probably not ethylene sensitive. Use a germicide or commercial postharvest solution.
LEPIRONIA  
**Botanical name:** *Lepironia articulata.*  
**Common name:** Digeri sticks.  

Used for foliage. Use a germicide or commercial postharvest solution.

LEUCOPOGON  
**Botanical name:** *Leucopogon verticillatus.*  
**Common name:** Tassel flower.  

Use a germicide or commercial postharvest solution.

LOMATIA  
**Botanical name:** *Lomatia* species.  
**Common name:** Lomatia, Crinkle bush.  

Used for foliage. Use a germicide or commercial postharvest solution.

LOPHOMYRTUS  
**Botanical name:** *Lophomyrtus ralphii.*  
**Common name:** Lophomyrtus.  

Used for foliage. Harvest time affects vase life, as soft tips wilt easily. Use a germicide or commercial postharvest solution. Stems can be stored for up to 5 weeks and still have 2 weeks vase life. The stems of *L.* ‘Krinkly’ are ethylene sensitive, and STS treatment stops leaf drop and increases vase life.

LYCOPODIUM  
**Botanical name:** *Lycopodium cernuum.*  
**Common name:** Coral fern.  

Used for foliage. Use a germicide or commercial postharvest solution.

LYSINEMA  
**Botanical name:** *Lysinema ciliatum.*  
**Common name:** Curry and rice.  

Use a germicide or commercial postharvest solution.
MACROZAMIA
Botanical name: Macrozamia communis.
Common name: Macrozamia, Burrawang.

Used for foliage. Use a germicide or commercial postharvest solution.

MELALEUCA
Botanical name: Melaleuca nematophylla, M. uncinatum, Melaleuca species.
Common name: Bottlebrush.

Harvest when individual flowers are starting to open on flower head. Use a germicide or commercial postharvest solution.

MICROMYRTUS
Botanical name: Micromyrtus ciliata.
Common name: Fringed heath myrtle.

Pick when half the flowers are open. Use a germicide, hydrating solution or commercial postharvest solution to help the buds develop and open. Treat like Thryptomene.

MUSGRAVEA
Botanical name: Musgravea species.
Common name:

Used for foliage. Use a germicide or commercial postharvest solution.

PERSOONIA
Botanical name: Persoonia longifolia, P. virgata, Persoonia species.
Common name: Barker bush, Geebung.

Persoonia longifolia is used for foliage. Use a germicide or commercial postharvest solution. For other Persoonia species that are harvested when in flower, treat as for Grevillea.
**PETROPHILE**

Botanical name: *Petrophile* species.
Common name: Conesticks.

Harvest when half the individual flowers are open on flower head. Use a germicide or commercial postharvest solution.

**PLATYSACE**

Botanical name: *Platysace* species.
Common name: Valentine’s Lace.

Harvest with the flowers opening. The flowers of *Platysace lanceolata* are not sensitive to ethylene. Use a germicide or commercial postharvest solution.

**PODOCARPUS**

Botanical name: *Podocarpus drouynianus*.
Common name: Emu grass.

Used for foliage. Use a germicide or commercial postharvest solution.

**PTILOTUS**

Botanical name: *Ptilotus exaltatus, P. obovatus, Ptilotus* species.
Common name: Ptilotus, Mulla mulla.

Pick with the flowers opening. *Ptilotus* flowers have a long life and retain their color and shape after harvest. Use a germicide or commercial postharvest solution. An overnight treatment with Chrysal OVB® improved flower opening and other germicides or hydrating solutions may do the same. Flowers are probably not sensitive to ethylene. Bunches of 5 and 10 stems are common. Sleeves, or paper between layers of flowers, may be useful to stop flowers interlocking. The hairs on some species or varieties can cause irritation and allergy. *Ptilotus* can be used as a dried flower.

**PYCNOSORUS**

Botanical name: *Pycnosorus globosus*.
Common name: Billy buttons.

Use a germicide or commercial postharvest solution. This flower can also be dried and dyed.
REGELIA
Botanical name: Regelia species.
Common name: Regelia.

Harvest when half the individual flowers are open on the flower head. Use a germicide or commercial postharvest solution.

SCHOLTZIA
Botanical name: Scholtzia involucrata, Scholtzia species.
Common name: Scholtzia.

Pick when half the flowers are open. Use a germicide, hydrating solution or commercial postharvest solution to help the buds develop and open. Treat like Thryptomene. *S. involucrata* has a vase life of at least 7 days.

STENANTHEMUM
Botanical name: Stenanthemum scortechinii.
Common Names: Corroboree flower, Snowballs. See Cryptandra.

Use a germicide or commercial postharvest solution. Can survive without postharvest cooling. Vase life is up to 3 weeks. Flowers can also be used dried and dyed.

STICHERUS
Botanical name: Sticherus umbellatus.
Common name: Fine leaf umbrella fern.

Used for foliage. Use a germicide or commercial postharvest solution.

STIRLINGIA
Botanical name: Stirlingia latifolia.
Common name: Stirlingia.

*Stirlingia* is usually picked from bush or managed stands. They are sold fresh, dried, dyed and painted. Only about 15% of bush-picked stems are suitable for sale. They are picked when the fruit, or "bobbles", are fully mature and silvery. Stems must have a good number of bobbles, evenly spread on the stem. If they are to be used as fresh flowers use a germicide or commercial postharvest solution. (Source: Reid 1998).
TEMPLETONIA  
Botanical name: *Templetonia retusa*.  
Common name: Retusa.

Used for foliage. Use a germicide or commercial postharvest solution.

XANTHORRHOEA  
Botanical name: *Xanthorrhoea* species.  
Common name: Xanthorrhoea, Steel grass.

Mainly used for foliage. Use a germicide or commercial postharvest solution.

ZIERIA  
Botanical name: *Zieria* species.  
Common name: Zieria (related to Boronia).

Harvest with the individual flowers opening. Use a germicide or commercial postharvest solution. Flowers of *Zieria cytisoides* are not sensitive to ethylene.

TROPICAL FOLIAGE  
Handle at 10°C to 15°C. (e.g. *Alloxylon, Darlingia, Stenocarpus, Placospermum*).
5. Further information on postharvest treatments and handling

It has not been possible to provide detailed advice on all aspects of postharvest handling. In several areas we have only provided a list of reference materials and sources of further information.

5.1 Bush picking

Picking from bush, or managed bush, on public or private land has been an important part of the Australian wildflower industry.

Many species are protected. A licence or permit from the appropriate State authority, is needed for picking, trading in and sometimes cultivating protected species. For example:

- WA: Department of Conservation and Land Management
- Victoria: Department of Natural Resources and Environment
- Queensland: Environment Protection Authority.

Fines apply for unauthorised picking.

Some authorities require certain bunch sizes. Check with your local authority.

It is not possible to control insect pests in bush stands because there is a large range of flower and insect species present and insects will continually visit from surrounding bush. In regenerating bush and areas of a single species, insecticide sprays may work. Flowers picked from bush stands may need extra care to make sure that postharvest pest control is effective.

If flowers are cut from plants with low vigor, the vase life may be shorter than in flowers from vigorous plants. For example, flowers of bush picked *Chamelaucium* had half the vase life of those from cultivated plants.

It is important to place flowers into water and cool them soon after harvesting.

Careful grading to ensure a good quality product is likely to be important.
5.2 Cold rooms, measuring temperature and humidity, forced-air cooling

Cold room design

It is best to get a room designed, or buy a room, from a reputable refrigeration engineer or contractor with experience in horticulture.

When designing or choosing a cold room the following things need to be considered.

- **Site and access**: Ideally, a cold store should be built within a packing shed. This shades the cold room from the sun and lowers the heat load on the outside of the room. It also makes it quick and easy to move flowers between the packing shed and cold room. The cold room needs to have easy access for delivery vehicles, so flowers can be quickly loaded from the cold room into trucks. The refrigeration equipment should be located outside the packing shed and protected from the weather.

- **Size**: This is worked out from the amount of flowers to be held at any one time, particularly at the peak of the season, and the space that’s needed for moving flowers in and out of the cold room. Doors and aisles inside the cold room should be wide enough for pallets (1165mm square) on hand trolleys (or forklifts). Allow space for a forced-air cooling unit and for racking, if necessary. At least 500mm of space is needed above the flowers for good air movement. A shape as near as possible to a cube (equal length, width and height) will keep insulation and refrigeration costs down.

- **Floor**: An insulated, reinforced concrete floor should be used, with the level of the floor the same as the packing shed. A non-slip floor surface and drainage would be helpful.

- **Insulation**: Insulating the walls and ceiling is necessary to reduce heat movement into the cold room. This reduces the power needed to keep the room cold. There are several different insulating materials available. Polystyrene, in sandwich-metal panels, is often used in horticultural cold rooms. While 100mm thickness is enough, there are energy savings to be made by using 150mm panels. A water barrier is required on the outside of the insulation to prevent moisture in the air from forming droplets of water in the insulation. This prevents the insulation from working properly. The outer walls of the cold room have to be completely sealed.

- **Doors**: Doors need to seal well and be large enough to move pallets etc. through. To reduce hot air coming into the room when the door is open, a plastic strip curtain should be placed across the inside of the doorway. Automatic doors would be an advantage.

- **Lights**: Lights must be bright enough so that staff can see the flower quality and read labels. If proteas are an important crop, then the fluorescent lights need to be as bright as in a bright room or office to reduce leaf blackening.
• **Refrigeration equipment:** A refrigeration engineer or contractor can design the equipment needed. The accurate information they need to be given to design the store includes these details.
  – Outside temperature (e.g. maximum in summer).
  – Flower temperature coming into the room (e.g. maximum in summer).
  – Final temperature, e.g. 2°C to 4°C.
  – The time in which cooling is to be achieved.
  – Whether forced-air cooling is required.
  – Rate of air exchange for ventilation (e.g. one change per hour).
  – Average daily quantity of flowers (weight).
  – Peak daily quantity of flowers (weight).
  – Plans for future expansion of production.
  – Layout in the store: flowers, access space, lights etc.
  – Humidity required; high humidity can be achieved at a cost.
  – Air movement: high enough to cool the flowers but not high enough to dry them out.

• **Temperature control:** Electronic thermostats, with a 0.5°C differential, give good temperature control. Electronic thermometers for the thermostats should be either placed amongst the flowers or in a well ventilated spot.

For further information on cold room design:

- Dahlenburg, Tugwell and Hill (2001).
- Internet site: [www.sardi.sa.gov.au](http://www.sardi.sa.gov.au/) and go to Horticulture then Cool Chain (and find the entry point)
- Story and Simons (1989).
- Horticultural refrigeration engineers and suppliers, e.g. Yellow Pages under “Cold room builders &/or designers”.

**Measuring temperature and relative humidity**

The most useful devices for measuring temperature are:

- direct reading thermometers – red spirit or mercury
- remote reading thermometers – dial or electronic
- temperature loggers
- temperature sensitive labels.

**Direct reading thermometers**

- Red spirit in glass thermometer – inexpensive, easy to read, but only accurate to the nearest 0.5°C.
- Mercury in glass thermometer – inexpensive, accurate, difficult to read in dim light, a health risk if the mercury comes out of broken thermometers.
Care should be taken to place the thermometer away from heat in walls, doors, fans and motors.
The bulb of the thermometer should be placed in a small bottle of water or in a piece of polystyrene foam or cork (about 100 x 50 x 50mm) so that the thermometer doesn't warm up once a door is opened or someone breathes on it while reading it.

**Remote reading thermometers**

- Dial thermometers have a dial outside the cold room and the sensing bulb inside.
- Electronic (resistance) thermometers are resistance metal thermometers, thermocouples or thermistors. They can be attached to a meter, a computer for continuous monitoring, a temperature controller, and an alarm. Many individual sensors can be connected to the one meter or computer.

Every cold room should have a remote thermometer, so the temperature can be easily and frequently read from outside the room.

**Temperature loggers**

These are small electronic devices that measure temperatures and keep a record of the data over time. They are small enough (e.g. 5cm x 5cm x 2cm) to fit into a bunch or carton of flowers. They can be used to measure the temperature of flowers throughout the handling chain. Before each trip the loggers are programmed by a simple computer program and after the trip the data is loaded onto the computer and recorded as a table or graph. Getting the loggers back e.g. from exporters, importer or retailers requires some planning and cooperation. See Section 5.18 for suppliers.
Temperature sensitive labels

These change color if the temperature goes over a certain level or if the temperature is above a certain level for a certain time. They can be attached to flower sleeves, cartons or pallets. They cost about $1 per label and can be used only once. See Section 5.18 for suppliers.

Checking the accuracy of thermometers

All thermometers should be regularly checked to make sure they are reading the temperature correctly. The most important thing to check is that the 0°C point on the scale matches with the temperature of melting ice.

The technique for checking the zero point is as follows:

- Crush enough ice to fill a bucket. (Make ice from deionised, distilled or pure water).
- Top the bucket full with just enough cold water.
- Put the bucket into a cold room for a few hours, so the temperature of the mixture can become stable. Both ice and water must be present.
- Put the glass thermometer in the bucket so the entire bulb and most (at least 5cm) of the column are covered. With remote-reading thermometers only the bulb needs be fully in the bucket of ice and water.
- Leave for at least 15 minutes to stabilise in the cold room.
- Read each thermometer and record the number of degrees it shows above or below 0°C.
- Attach a tag with the amount of the error to the glass thermometer or to the dial of the remote reading thermometer, so the error can be added or subtracted each time the thermometer is read. For example write “True 0°C = x°C on thermometer”. From this the actual temperature can be calculated as the thermometer reading minus x.

Position of thermometers in cold rooms

The thermometer probe is best hung among the flowers or, if a permanent position is needed, mounted above the flowers, but away from local heating or cooling. It is best to monitor both flower temperature and air temperature in a few different parts of the cold room. The most economical way to monitor the temperature of a number of points is to use a single electronic meter unit and connect the required number of sensors to it.

Recording temperatures

It is important to measure and record cold room temperatures at least daily. See Work Sheet 8, Section 6.
Humidity measurement

Humidity can be measured using a wet and dry bulb thermometer set. For more accurate measurements in a cold room, a special psychrometer is needed.

Electronic humidity meters have a hand-held probe and a small meter-readout. The probes can also be connected to a data-logger or computer. Some meters are only accurate to ± 5% at the high humidity of 90% found in cold rooms and this may not be accurate enough. Others are accurate to ± 1% but they are more expensive than the less accurate meters. The meters need to be regularly checked and adjusted, using either standard solutions, or by the manufacturer.

Further information

For further information on measuring temperature and humidity see:

- Faragher (2000)
- Hill (2001)
- Internet site: www.sardi.sa.gov.au/ and go to Horticulture then Cool Chain (and find the entry point)

Forced-air cooling

Forced-air (or pressure) cooling provides a quick, efficient and economical way of cooling large volumes of flowers. It also allows efficient handling of flowers, as they can be rapidly packed into cartons, and then, cooled, in the carton.

The way forced-air cooling works is that cold air is pulled through the cartons by placing the cartons against a fan, or a cooling wall containing fans. The fans suck the air from the cold room through the vented cartons.

The advantages are as follows.

- Rapid cooling, four to ten times faster than just putting boxes into a cold room, thereby reducing quality loss. Forced-air cooling can cool flowers to cool room temperature in 40 minutes to 3 hours depending on the starting temperature, the amount of flowers and the rate of air movement.
- Large volumes of flowers can be cooled quickly.
- More efficient use of the cold room because cooling takes a shorter time.
- More energy efficient than regular (passive) cooling when large volumes of flowers have to be cooled.
- An available cold room, with adequate refrigeration capacity can be converted with only a relatively small investment in fans and structures.
The costs are:

- fans and structures to hold them in place
- extra refrigeration capacity to handle the rapid cooling, if this is necessary
- refrigeration that provides higher humidity air e.g. 80 to 85% rather than 50 to 60%, if necessary
- more electricity may be used to enable the rapid cooling.

Experienced growers and exporters who’ve used this system believe that the benefits outweigh the costs, particularly if large volumes of flowers are being handled.

Several different arrangements of flower cartons and fans can be used. Two are:

- tunnel arrangement with a portable, pallet mounted fan
- cooling wall with permanently mounted fans.

**Tunnel**

Two parallel rows of cartons are stacked approximately 0.7m to 1.0m apart, next to an exhaust fan. The aisle between the cartons and the open end of the aisle are covered with a cloth or plastic sheet to create a tunnel. The fans suck air from the cold room through the vented cartons.

![Force-air cooling using a tunnel](From Story and Simons 1989).

**Cooling wall**

A wall or plenum chamber is built in to one end or side of the cold room, with fans built into the wall. Stacks or pallets of cartons are placed against openings in the wall. The fans pull air from the room through cartons, into the chamber and out into the room again.

![Forced-air cooling using a cooling wall](From Watkins and Ledger 1990).
Cartons are quickly moved from the cooler once they are cold, to the regular cold room space, so that they don’t dry out from continued air flow over them.

Forced-air cooling needs to be installed by an expert in systems for horticultural products. The maximum amount of refrigeration needs to be great enough to remove the heat load created by forced-air cooling. It is best that the air humidity is at least 85%. This requires either a normal refrigeration system designed to achieve high humidity, or a special high humidity systems that passes the cold air through water to achieve 98% RH. Fans need to be selected to deliver the right air volume and pressure difference for the number and size of cartons to be cooled.

Cartons need vents in the ends or sides, of approximately 5% of the area of the end or side. There should be nothing to prevent air flow, such as sleeves or paper, inside the carton. After cooling, the vents on some cartons can be closed, or labels can be stuck over them, if the cartons are going to remain cold. However, if the cartons are going to warm up for a long time, it may be necessary to leave the vents open so the flowers don’t over-heat. The holes may also need to be left open to satisfy Japanese quarantine requirements, in case the flowers need to be fumigated.

For further information on forced-air cooling refer to:

- Story and Simons (1989)
- Watkins and Ledger (1990)
- Palmer (2001)
- Internet site: www.sardi.sa.gov.au/ and go to Horticulture then Cool Chain

5.3 Sensitivity to ethylene and anti-ethylene treatments

Sensitivity to ethylene

Not all the species or varieties in any particular genus (e.g. Leptospermum) react the same way in response to ethylene, so it is important to know the sensitivity of each one.

To find out if a flower is sensitive to ethylene it is put in contact with ethylene and compared with a flower that has not been in contact. There are a few methods for testing ethylene sensitivity.

Apple in a bag test

A simple method is to put a few cut stems of the flower in each of two plastic bags (e.g. supermarket or garbage bag) with some wet paper towel and one or more apples or other ethylene producing fruit. See photos Section 2.6.

- Put a few similar stems in two other bags without an apple.
- Loosely close bags and keep at room temperature (15°C to 25°C) for 24 hours.
- Remove flowers and examine.
If there is a noticeable drop of individual flowers, discoloration or wilting in the bag with fruit but not in the bag without fruit, this is likely to be ethylene damage. If there is no difference, it may be worth keeping the flowers in vases for a few days to see if any difference develops. If there seems to be ethylene damage, it is worth repeating the test, or doing a more precise test, to confirm ethylene sensitivity.

**Apple in a bucket test**

A similar method is described by Staby (1994).

- Cut flowers and place in four vases.
- Place each vase under an upturned 10l to 20l bucket on a bench or table.
- Place apples under two of the buckets but not under the other two.
- Leave at room temperature (15°C to 25°C for 1 to 2 days).
- Remove the buckets and examine for damage associated with the apples.

**Ethrel® dip**

Ethrel® is a fruit ripening chemical that releases ethylene once it is inside the fruit. Flowers can be dipped in a solution of Ethrel® (e.g. 500ppm as used for fruit ripening) and then placed in a vase to observe the effect. Another vase of untreated flowers is used for comparison.

**Ethylene test**

A more precise method is to put flowers in a gas tight container and inject ethylene. This needs some simple laboratory equipment and skills. See photo Section 2.6.

- Place flowers in vases in a large closed space (e.g. 150l for 10 stems), with a solution that will absorb carbon dioxide given off by the flowers (e.g. saturated sodium hydroxide).
- Use several such closed containers, some with ethylene at various concentration (usually 0.1, 1 and 10ppm) injected into them, and some with no ethylene.
- Remove flowers from the containers after 12 hours, 24 hours or longer and observe for signs of ethylene damage.
### Ethylene sensitivity of Australian and related flowers

The table below summarises the available information on ethylene sensitivity and the effects of anti-ethylene treatments.

<table>
<thead>
<tr>
<th>Flower Family</th>
<th>Ethylene sensitivity</th>
<th>Effects of ethylene</th>
<th>Effects of anti-ethylene treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Acacia</strong></td>
<td>Sensitive species are: <em>A. baileyana</em>, <em>A. dealbata</em>, <em>A. farnesiana</em>, <em>A. georginae</em>, <em>A. horrida</em>, <em>A. linifolia</em>. Species that are not sensitive: <em>A. floribunda</em> <em>A. subulata</em>.</td>
<td><em>A. baileyana</em> dropped flower heads and buds in response to high concentrations (25 to 100ppm), but this is rarely found in normal handling.</td>
<td>STS did not increase the vase life of <em>A. baileyana</em>.</td>
</tr>
<tr>
<td><strong>Alloxylon pinnatum</strong></td>
<td>Slightly sensitive.</td>
<td>Individual flowers drop.</td>
<td>1-MCP protected against ethylene damage, increased the flower life and reduced individual flower drop.</td>
</tr>
<tr>
<td><strong>Anigozanthos</strong></td>
<td>Not sensitive. The following hybrids are not sensitive: <em>Anigozanthos flavidus</em> x <em>A. preissii</em> 'Regal Claw', <em>A. pulcherrimus</em> x <em>A. flavidus</em> 'Gold Fever', <em>A. pulcherrimus</em> x <em>A. flavidus</em> 'Harmony'.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Backhousia myrtifolia</strong></td>
<td>Sensitive.</td>
<td>Flower drop.</td>
<td></td>
</tr>
<tr>
<td><strong>Baeckea</strong></td>
<td><em>B. virgata</em> is sensitive. It is not known if <em>B. behrii</em> is sensitive.</td>
<td>Petal drop.</td>
<td>STS protected <em>B. virgata</em> against the effect of ethylene to cause petal drop. It did not stop natural drop. STS did not extend the life of <em>B. behrii</em>.</td>
</tr>
<tr>
<td><strong>Banksia</strong></td>
<td>Not sensitive.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Blandfordia grandiflora</strong></td>
<td>Not sensitive.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Boronia

<table>
<thead>
<tr>
<th>Ethylene sensitivity: B. heterophylla is sensitive to long exposure (72 hours) to high concentrations (10ppm). B. crassipes x B. heterophylla 'Lipstick' is probably sensitive.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effects of ethylene: In B. heterophylla, ethylene caused individual flower wilting and drop and leaf drop.</td>
</tr>
<tr>
<td>Ethylene production: In B. heterophylla ethylene production increased at the same time as individual flowers wilted.</td>
</tr>
<tr>
<td>Effects of anti-ethylene treatments: STS extended the vase life of B. heterophylla and B. crassipes x B. heterophylla 'Lipstick' but not of B. clavata or B. muelleri 'Sunset Serenade'. STS and 1-MCP protected against the effects of ethylene on B. heterophylla.</td>
</tr>
</tbody>
</table>

### Callistemon (Bottle Brush)

| Ethylene sensitivity: Probably sensitive. |
| Effects of ethylene: Individual flowers drop off the flower head. |

### Ceratopetalum gummiferum (Christmas bush, Festival bush)

| Ethylene sensitivity: May be sensitive e.g. after water stress. |
| Effects of ethylene: Individual flowers and sepals drop. |
| Effects of anti-ethylene treatments: 1-MCP protected against the effect of ethylene to cause flower, sepal drop. |

### Chamelaucium (Geraldton Waxflower)

| Ethylene sensitivity: Chamelaucium uncinatum and C. axillare are sensitive to very low levels of ethylene, e.g. 0.01ppm to 0.1ppm for 12 hours at 20°C. Both buds and flowers are sensitive. C. ciliatum is probably not. Different varieties of C. uncinatum have different sensitivity, e.g. ‘Paddy’s Late’ is super sensitive. |
| Effects of ethylene: Flower drop. Immature buds also drop when in contact with ethylene. |
| Ethylene production: Individual flowers produce ethylene as they age. Botrytis infection is common and this increases ethylene production and flower drop. |
| Effects of anti-ethylene treatments: STS and 1-MCP reduced flower drop caused by lack of water or dry transport. STS and 1-MCP protected against the effects of applied ethylene. 1-MCP at low doses only gave protection for 4 days. |

### Conospermum (Smoke Bush)

| Ethylene sensitivity: Not sensitive. |

### Corynanthera flava (Golden Cascades)

| Ethylene sensitivity: Not sensitive. |

### Crowea exalata

<p>| Ethylene sensitivity: Probably sensitive. |
| Effects of anti-ethylene treatments: STS increased vase life and reduced flower drop. |</p>
<table>
<thead>
<tr>
<th><strong>Eriostemon (Philotheca)</strong></th>
<th>Ethylene sensitivity: Sensitivity is not known. <em>Philotheca scaber</em> was not sensitive in one experiment. <em>P. verucossus</em> and <em>P. myoporoides</em> (previously <em>E. myoporoides</em>) drop their petals, so it would not be surprising if they are sensitive.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eucalyptus (Gum)</strong></td>
<td>Ethylene sensitivity: The foliage of two species tested was not sensitive: <em>E. crenulata</em>, <em>E. gunnii</em>. Stamens of some open flowers drop in response to ethylene. Ethylene production: Very slight production by two foliage species immediately after harvest (<em>E. crenulata</em>, <em>E. gunnii</em>); large levels in another species after 2 to 4 weeks’ storage.</td>
</tr>
<tr>
<td><strong>Geleznowia verrucosa (Yellow Bells)</strong></td>
<td>Ethylene sensitivity: Not sensitive.</td>
</tr>
<tr>
<td><strong>Grevillea</strong></td>
<td>Ethylene sensitivity: Most are sensitive including the following hybrids: ‘Honey Gem’, ‘Kay Williams’, ‘Majestic’, ‘Misty Pink’, ‘Sandra Gordon’, ‘Robyn Gordon’ (slightly), ‘Sylvia’. The following are not sensitive: <em>G. hookeriana</em>, <em>G. thelmanniana</em>. Effects of ethylene: Individual flowers drop off the flower head. Ethylene production: Some grevilleas produce ethylene as they age. This probably causes flower split, which is where the flower tube comes away from the stem (“slippers”), and individual flower drop (<em>G. ‘Sylvia’</em> and <em>G. ‘Majestic’</em>). Effects of anti-ethylene treatments: STS reduced natural abscission in <em>G. ‘Majestic’</em>. STS and 1-MCP protected against the effects of applied ethylene. STS protected <em>G. ‘Honey Gem’</em> and <em>G. ‘Majestic’</em> against ethylene. 1-MCP protected <em>G. ‘Sylvia’</em>, but at low doses, it only gave 2 days protection.</td>
</tr>
<tr>
<td><strong>Hakea</strong></td>
<td>Ethylene sensitivity: May be sensitive. There is some evidence of sensitivity in: <em>H. francisiana</em>, <em>H. laurina</em>. Effects of ethylene: Individual flowers drop off the flower head.</td>
</tr>
<tr>
<td><strong>Ixodia achillaeoides sub-species alata (South Australian Daisy)</strong></td>
<td>Ethylene sensitivity: Not sensitive.</td>
</tr>
</tbody>
</table>
| **Leptospermum** (Tea Tree) | Ethylene sensitivity: Many are sensitive. The following are sensitive: *Leptospermum morrisonii* (green-leaved Queensland form), *L. petersonii*, *L. rotundifolium ‘Lavender Queen’,* *L. scoparium* hybrids. The following is not sensitive: *L. morrisonii* (burgundy-leaved form).

Effects of ethylene: Petals, individual flowers and leaves drop off; petals close, flowers dry. It appears that flower drop only occurs if the stems are in high humidity, e.g. in a package.

Ethylene production: Ethylene production by *L. scoparium* stems increased as they aged.

Effects of anti-ethylene treatments: STS and 1-MCP protected against the effects of applied ethylene. STS protected *L. rotundifolium* and *L. scoparium* hybrids. 1-MCP protected *L. petersonii*. |
| **Leucadendron** | Ethylene sensitivity: Not sensitive. |
| **Leucospermum** (Pin Cushions) | Ethylene sensitivity: Not sensitive. |
| **Lophomyrtus x ralphii ‘Krinkly’** | Ethylene sensitivity: Probably sensitive.

Effects of ethylene: Leaf drop.

Effects of anti-ethylene treatments: STS reduced leaf drop. |

Effects of ethylene: Bud and stamen drop.

Effects of anti-ethylene treatments: STS and 1-MCP protected against the effects of applied ethylene. |
| **Ozothamnus** (Rice Flower) | Ethylene sensitivity: Probably sensitive. Not very sensitive to applied ethylene, but it seems to be affected by internal, self produced ethylene, as chemicals that block ethylene production and action, delay leaf blackening and death.

Effects of ethylene: Leaf blackening and death.

Ethylene production: High.

Effects of anti-ethylene treatments: STS delays leaf blackening and death and increases vase life (broad leaf form in Queensland and *O. ‘Jacob's Pink’* a mid-leaf form in Victoria). 1-MCP had no clear effect on *O. ‘Cooks’ Tall Pink’*. Chemicals that block ethylene production sprayed on the foliage, extend vase life. |
| **Platysace lanceolata** (Valentine’s lace) | Ethylene sensitivity: Not sensitive. |
| **Protea** | Ethylene sensitivity: Not sensitive. |
| **Rhodanthe chlorocephala**  
sub-species *rosea*  
(*Helipterum roseum*)  
(Everlasting daisy) | Ethylene sensitivity: Not sensitive. |
|---|---|
| **Swainsona Formosa**  
(Sturt’s desert pea) | Ethylene sensitivity: May be sensitive.  
Effects of anti-ethylene treatments: STS increased the vase life of the flower head. |
| **Telopea**  
(Waratah) | Ethylene sensitivity: The following are sensitive: *T. speciosissima, T. ‘Shady Lady’.*  
Effects of ethylene: Individual flowers come away and become dry and blue.  
Ethylene production: Flowers produce ethylene as they age.  
Effects of anti-ethylene treatments: STS and 1-MCP did not increase vase life. 1-MCP protected against the effect of applied ethylene. |
| **Thryptomene**  
(*T. calycina = Grampians thryptomene, Grampians lace flower*) | Ethylene sensitivity: Probably sensitive. The following are sensitive: *T. calycina, T. saxicola* (white form). *T. saxicola ‘Payne’s hybrid’* is probably sensitive, at least when the individual flowers are fully open.  
Effects of ethylene: Individual flowers drop. Flower drop may only occur if the stems are in high humidity e.g. in a package. Sometimes flower drop occurs only when the flowers are fully mature or old.  
Effects of anti-ethylene treatments: 1-MCP protected against the effect of applied ethylene to cause flower drop in *T. saxicola* (white form). |
| **Verticordia**  
(Feather Flower) | Ethylene sensitivity: *V. nitens* is sensitive. The following are not sensitive: *V. chrysantha, V. densiflora, V. plumosa.*  
Effects of ethylene: Individual flowers drop.  
Effects of anti-ethylene treatments: 1-MCP and STS protected against the effects of applied ethylene on *V. nitens*. |
| **Zieria cytisoides** | Ethylene sensitivity: Not sensitive. |
5.4 Anti-ethylene treatments

Commercial STS products and suppliers

Several products are available around the world, but few appear to be available in Australia.

Chrysal AVB is available in Australia through Chrysal suppliers (See Section 5.18 below for suppliers). Follow the label instructions.

Daly Laboratories Pty Ltd in Perth makes up 40mm (silver concentration) stock solutions of STS (See Section 5.18 below for contact details). Follow the label instructions, or the recipes below for diluting 40mm stock solution.

Commercial solutions have a life of 3 to 12 months depending on the formulation and the storage temperature. They should be stored in plastic or glass, in the dark and it is probably best to store them at 2°C to 4°C. It is best to buy only what is needed in the short term and use it quickly, as soon as possible after it’s made up.

Remember! Silver is considered a hazardous poison so handle STS solutions as carefully as pesticides – wear protective clothing, waterproof apron, gloves and glasses.

STS recipes

Making up STS requires some simple laboratory skills and equipment, and safety precautions.

Silver thiosulphate (STS) contains silver and thiosulphate. The concentration of STS solutions is given in chemical units of millimolar (mM) amounts of silver. A 4mM solution contains 4 millimoles of silver (from 0.68g of silver nitrate) per litre plus 16 millimoles of thiosulphate (from 2.53g of sodium thiosulphate (the anhydrous form)).

STS is usually used in one of the following way.

- A concentration of 4mM (silver) for 15 to 60 minutes at around 20°C depending on how quickly the solution is taken up. See STS uptake below.
- A concentration of 0.2mM (silver) for 16 hours (overnight) at 2°C to 4°C.

Making the concentrated stock solution

A concentrated (40mM silver) stock solution is made up and then this is diluted with water to make the final 4mM or 0.2mM solution. The following recipes are from an article by Joyce (1992).

To make 2l of the stock solution (40mM silver)

- Use clean glass or plastic containers.
• Dissolve 13.6g of silver nitrate in 1l of good quality water (e.g. rain, distilled, or deionised water).
• Dissolve 50.6g of sodium thiosulphate (anhydrous) or 79.4g of sodium thiosulphate (pentahydrate) in 1l of good quality water.
• Stir vigorously and slowly pour the silver nitrate solution into the sodium thiosulphate solution to obtain a final volume of 2l.
• If necessary, store the stock solution in a sealed, dark glass or plastic container and keep cold, e.g. at 2°C to 4°C.

Silver nitrate and sodium thiosulphate (either anhydrous or pentahydrate) are available from laboratory or industrial chemical suppliers. Check a few suppliers to get the best price. Use protective clothing, including gloves and eye-protection. Use skin-protective barrier cream. If dust is created use a respirator. Change contaminated clothing. Wash hands and face after using silver nitrate.

To measure small amounts (1 or 2g) of dry materials, a sensitive balance that will weigh to the nearest gram, or approximate teaspoon measures are needed. Make sure teaspoons are clearly marked for flower use only and kept in the laboratory or chemical store. The approximate teaspoon measures needed to make up 2l of stock STS solution:

13.6g silver nitrate = 1 teaspoon
50.6g sodium thiosulphate (anhydrous) = just over 2 tablespoons
79.4g of sodium thiosulphate (pentahydrate) = 4 tablespoons

To measure larger amounts of dry materials, use kitchen scales - marked for flower use only, and kept in the laboratory or chemical store.

Use clean plastic or glass containers and equipment. Metal containers will react with the silver and STS solutions and make them not work.

It is best to make up only enough concentrate for a short period of use, e.g. a week, and use it, as soon as possible after it’s made up. If it might be too old, make some working solution and then test it to see if it’s okay. (See below: Testing whether STS solutions are fit for use).
To make up working solutions

To make up the working solution for treating flowers at room temperature for 15 minutes (4mM silver), do the following.

- Take 1l of stock solution and add 9l of water to make 10l of working solution. Use water that is as pure as possible e.g. rain water or town water without chlorine.

To make up the working solution for treating flowers in the cold room for 16 hours (0.2mM), do the following.

- Take 50ml of stock solution and add 9.950l of water.

Use good quality water to make up the working solution– rain water or town water with no chlorine or other salts – otherwise silver can drop out of the solution and the STS becomes useless. A brown precipitate (layer on the bottom of the container), or cloudiness, are signs of preparation problems and the solution may be useless. If there is any doubt about whether the STS solutions are fit for use, test them as described below (testing whether STS solutions are fit for use).

The recipes above make 2l of stock solution and 10l of working solution. These amounts can be increased by doing the following.

- Multiplying everything by 10 to give 20l of stock solution and 100l of working solution.
- Multiply everything by 100 to give 200l of stock solution and 1000l of working solution.
Sometimes working solutions of 4mM or 0.2mM may be too weak. This can happen when in these situations.

- Uptake is too slow at low temperature or high humidity – 0.5mM may be better than 0.2mM.
- Faster uptake is required for shorter periods in the cold room - 0.5mM will be better than 0.2mM.
- Fast uptake is required where flowers are on a conveyor belt with their stems in a bath of STS for only 5 minutes – 8mM for 8 minutes will be better than 4mM for 15 mins.

The following table shows the amounts of stock solution and water needed to make up different final STS concentrations.

<table>
<thead>
<tr>
<th>Final STS concentration (mM)</th>
<th>Stock solution (40mM)</th>
<th>Water to make up 10l of working solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>50ml</td>
<td>9.950l</td>
</tr>
<tr>
<td>0.5</td>
<td>125ml</td>
<td>9.875l</td>
</tr>
<tr>
<td>1</td>
<td>250ml</td>
<td>9.750l</td>
</tr>
<tr>
<td>4</td>
<td>1l</td>
<td>9l</td>
</tr>
<tr>
<td>8</td>
<td>2l</td>
<td>8l</td>
</tr>
<tr>
<td>16</td>
<td>4l</td>
<td>6l</td>
</tr>
</tbody>
</table>

Handle STS solutions as carefully as pesticides– wear protective clothing, waterproof apron, gloves and eye protection.

**Testing whether STS solutions are fit for use**

This is a simple test to see if STS is in the right form to work effectively (Joyce 1994). It can be done by someone with simple laboratory equipment and skills. The general idea is to mix samples of the STS solution prepared at working strength (e.g. 0.2mM, 0.5mM or 4mM silver or Ag⁺). The STS solution is mixed with a ‘strong’ testing agent (potassium iodide, KI) and (sodium chloride, NaCl) a ‘weak’ testing agent. The reactions are then observed.

**Preparation of testing agent solutions**

Potassium iodide (KI) and sodium chloride (NaCl) can be bought from laboratory supply companies or chemist shops. Shop around to find the best price. Both testing agents are used at a concentration of 2.0M (molar). The solutions should be prepared using distilled water in the following ways:

- **Potassium iodide:** The solution should be prepared with 33.2g KI dissolved in distilled water and made up to a final volume of 100ml.
- **Sodium chloride:** The solution should be prepared with 11.7g NaCl dissolved in distilled water and made up to a final volume of 100ml.
Performing the test

Use two sets of three clean and dry glass containers (e.g. 50ml test tubes). These six containers should be cleaned as follows: a detergent wash, a tap water rinse and then two distilled water rinses. The two sets are duplicates and the three treatments will be:

1. Distilled water addition (the control treatment)
2. KI addition (the strong testing agent) and
3. NaCl addition (the weak testing agent).

Measuring cylinders, medicine glasses (labelled for laboratory use only), eye-droppers, or pipettes are needed to measure the STS, the two testing agents and distilled water. A separate cylinder/medicine glass/ pipette is needed for use with each different solution

The procedure is as follows.

Add 1ml of distilled water; to two tubes labelled ‘1’
Add 1ml of 2M KI; to two tubes labelled ‘2’,
Add 1ml of 2M NaCl; to two tubes labelled ‘3’

Finally add 20ml of the STS solution to be tested, to each of these tubes, 10 seconds later, observe the effect.

The results

Three results are possible and are shown in the table on the next page.

Result 1. Where the STS solution is working, the strong testing agent (KI) will give an undissolved white to yellow precipitate, which discolors (makes turbid) the solution in about 10 seconds. The weak testing agent (NaCl) however, will have no effect.

Result 2. If there is no precipitate, or turbidity, with the strong testing agent, then there is not enough silver in the solution.

Result 3. If precipitate (turbidity) is obtained with both the strong and the weak testing agents, there is silver in the solution, but it is in the wrong form to be taken up the flower stems.
Expected “strong” KI and “weak” NaCl test results for effective and ineffective STS solutions.

<table>
<thead>
<tr>
<th>Testing agent solution</th>
<th>Test solution</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Effective</td>
<td>Ineffective</td>
</tr>
<tr>
<td>Result 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Strong” KI</td>
<td>Turbid</td>
<td>STS complex formed OK – effective</td>
</tr>
<tr>
<td>“Weak” NaCl</td>
<td>Clear</td>
<td></td>
</tr>
<tr>
<td>Result 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Strong” KI</td>
<td>Clear</td>
<td>Insufficient silver – ineffective</td>
</tr>
<tr>
<td>“Weak” NaCl</td>
<td>Clear</td>
<td></td>
</tr>
<tr>
<td>Result 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Strong” KI</td>
<td>Turbid</td>
<td>STS complex not formed – ineffective</td>
</tr>
<tr>
<td>“Weak” NaCl</td>
<td>Turbid</td>
<td></td>
</tr>
</tbody>
</table>

The Queensland Wax and Native Flower Association has a test kit as part of their quality assurance procedures (see Crothers, Wells and Mahoney (1994)). An STS test kit is also part of the Anti-Ethylene Verification System (see below).

**STS Uptake**

The amount of STS solution taken up by the flowers is very important to the success of the treatment. If not enough is taken up the flowers will not be protected. If too much is taken up, they may be damaged.

Solution uptake depends on temperature, humidity, air movement, whether the stems were dry before treatment and when the stems were last cut.

A useful guide to how much solution needs to be taken up is given by Joyce (1992).

A 400g bunch of *Chamelaucium uncinatum* for example, needs to take up between 10g (or ml) and 50g (or ml) of 4mM solution.

If the amount of solution taken up is measured, the treatment can be stopped when enough has been taken up. One method of measuring uptake (Joyce (1992)) is as follows.

- Weigh two or three buckets containing the STS solution before the stems are added (weight 1). The weight needs to be measured to the nearest gram.
- Weigh the stems before they are put in the solution for treatment (e.g. three 400g bunches).
- After treatment, remove the stems from the bucket and shake excess STS off the stems into the bucket.
- Re-weigh the bucket and solution (weight 2).
- The difference between weight 1 and weight 2 is the weight of STS solution taken up by the stems.
• It is worth doing this in two or three buckets and working out the average uptake for a known amount of flowers, e.g. three 400g bunches.

See Work Sheet 4, Section 6 for an example of how to calculate STS uptake.

The uptake needed for different bunch sizes can be calculated e.g. a 200g bunch would only need to take up half as much, between 5g and 25g of 4mM solution.

If *Chamelaucium* flowers are treated with 0.2mM STS, e.g. in a cold room overnight (16 hours), they would need to take up 20 times the amount (4mM ÷ 0.2mM = 20), i.e. between 200ml and 1l of this less concentrated solution per 400g bunch.

It is not known how much STS other flowers require. It would be reasonable to start by assuming that a 400g bunch of similar flowers such as *Boronia*, *Thryptomene*, *Leptospermum*, *Verticordia*, or *Grevillea*, needs the same 10ml to 50ml (or 10g to 50g) of 4mM STS. To see whether this treatment protects the flowers, they could be exposed to ethylene, along with some untreated flowers, to see if any damage occurs. If the flowers are not protected the STS amount needs to be increased. If there is any STS damage on the flower (e.g. leaf blackening, flower blueing and death) the STS amount needs to be decreased. For example *Chamelaucium uncinatum* ‘Lollypop’ was damaged by uptake at the middle of the recommended range.

Another way to measure the amount of solution taken up, is to place bunches of flowers in a large (500ml) measuring cylinder (Hall and Mercy 1999). The operator measures when sufficient uptake has occurred (e.g. 10ml to 50ml per 400g bunch) and the treatment is stopped. (See below: Anti-Ethylene Verification System). See photos Section 2.6.

The grower or exporter who is treating the flowers will build up experience over time that will help them make sure the flowers take up the right amount of solution to protect them.

**Test whether STS or 1-MCP have protected flowers**

To test whether STS or 1-MCP have protected the flowers against ethylene the flowers can be exposed to ethylene using one of the methods described above (Section 5.3).

**Ethylene absorbing or destroying materials**

Several ethylene absorbing products are available as sachets, cylinders or plastic films or bags. Well known brand names include Ethysorb®, Purafil®, Bloomfresh® and Ethylene Control® (See Section 5.18 below for suppliers). There are mixed reports about how well these work.
At least one grower recommends lining *Boronia* cartons with ethylene absorbing film. However it is difficult to get enough ethylene absorbing material close to flowers in a bag, carton or cold room to absorb enough ethylene to prevent flower damage. These materials can absorb ethylene from air, so they may protect flowers from external ethylene sources. However they have limited ability to absorb ethylene from inside flowers (or fruit) that are producing their own ethylene e.g. *Chamelaucium* infected with *Botrytis*. In experiments with *Chamelaucium*, ethylene absorbents inside plastic bags slightly reduced drop in waxflower, but the plastic bags themselves, with or without an ethylene absorber, increased humidity and flower drop.

Ethylene scrubbers, machines that destroy ethylene by burning it (catalytic converters) or reacting it with ozone, are used in some cold rooms (e.g. for apples and nashis). While these can successfully reduce the ethylene level in the cold room, they have very limited capacity to remove ethylene from inside the individual flowers that are producing it (e.g. *Chamelaucium* infected with *Botrytis*.)

**Anti-ethylene verification system**

An integrated anti-ethylene system, to ensure sensitive flowers are protected, has been devised by Doug Hall of Innovating Horticulture Australia, in collaboration with industry members.

The system has three major components.

1. STS-Test Kit – used to work out the ‘health’ of STS solutions.
2. Volume Test Kit – used to monitor the uptake of the STS-pulse solution.
3. Ethylene-Challenge Kit – used to test sensitivity of plant material to ethylene.

![Schematic of the Anti-Ethylene Verification System (AEVS)](image)

Relationship of the three test procedures (STS-Test Kit, Volume Test Kit, and Ethylene-Challenge Kit) to the major production steps for ethylene sensitive crops such as *Chamelaucium uncinatum*. 

*Note* that C$_2$H$_4$ is the chemical formula for ethylene. From Hall & Mercy (1999).
In combination, these three components can be used to:

- assess if a variety requires anti-ethylene treatments
- make the most of anti-ethylene treatment application for individual grower conditions
- assess how well the STS or 1-MCP treatments work
- use STS or 1-MCP more cost-effectively, saving the grower money.

If 1-MCP is used, then only the ethylene challenge kit is required.

Strengths of the system are that it is quite cheap, easy to use and the results are easy to interpret. The system has been designed for use by industry members on a day to day basis as part of quality management. It is continuing to be developed and improved in collaboration with industry and RIRDC (RIRDC project IHA-1A). In particular, a range of kits is being developed to suit the specific needs of different types of export chains.

For further information see Hall and Mercy (1999).

### 5.5 Postharvest solutions

#### Preparing solutions

Take care in handling the ingredients of postharvest solutions, as the concentrated chemicals, particularly chlorine and citric acid, can cause injury. Use protective clothing, gloves and glasses.

To measure small amounts (1 or 2g) of dry materials use either a sensitive balance that will weigh to the nearest gram or approximate teaspoon measures. Make sure teaspoons are clearly marked for flower use only and are kept in the chemical store. To measure larger amounts of dry materials use kitchen scales marked for flower use only and keep in the chemical store.

To measure small volumes of liquids, e.g. 1ml, use a medicine glass, plastic measuring cylinder or eye-dropper marked for flower use only and keep in the chemical store.

Mix all ingredients thoroughly.

Use plastic containers where possible. Chlorine, citric acid, aluminium sulphate and commercial postharvest solutions may corrode metal containers.

Don’t store solutions as they may become contaminated with bacteria or break down.

Take care when handling solutions and avoid contact with skin and particularly with eyes.
Germicides

Chlorine germicides were discussed in Section 2.7. Other germicides are discussed here.

Quaternary ammonium germicides

Quaternary ammonium germicides work with some traditional flowers, particularly carnation and gypsophila. They don’t work and can even damage some other flowers. They have rarely been tested on Australian native flowers and their relatives. One is known to increase the vase life of Geleznowia but decrease the vase life of Eucalyptus crenulata foliage. Quaternary ammonium germicides are worth experimenting with because they may be very effective with some flowers. They can improve water uptake and are relatively safe to humans.

Quaternary ammonium germicides are also very useful for general hygiene and for washing equipment and buckets. The most common active ingredient is benzalkonium chloride. They are available in several commercial products: nappy wash solutions, nursery disinfectants, hospital disinfectants, fruit and vegetable washing solutions, swimming pool algacides (not all contain benzalkonium chloride) and at least two products made for flowers Physan and Chrysal OVB. These germicides are used at 200ppm, 0.2g of active ingredient per l. Because they are sold in dilute solutions, the concentration, or amount, of active ingredient (e.g. 150g/l or 15%) needs to be known before working out how much concentrate and how much water in the final flower solution.

For example, one commercial swimming pool algacide contains 15% benzalkonium chloride. To get 200ppm active ingredient it needs to be diluted.

\[
200 \text{ppm} \times \frac{1}{15\%} = \left(\frac{200}{1,000,000}\right) \times \left(\frac{100}{15}\right) = \frac{1}{750} = 1.3\text{ml/l}
\]

Physan 20 has been recommended for proteas and their relatives (Bottomley and Smee). It can be purchased from USA for approximately $A150 per gallon (= 4.5l) including shipping (20% active ingredient). It is expensive relative to local products such as swimming pool algacides, but it might be more effective on some flowers.

Hydroxyquinoline citrate and hydroxy quinoline sulphate

These germicides do work and improve water uptake and vase life of some flowers. However the Material Safety Data Sheet says “Laboratory studies have shown 8-hydroxyquinoline to be a possible mutagen” (i.e. it can alter chromosomes). For this reason, we don’t recommend it.

Hydrating solutions

These help the water to move up the flower stem, thus increasing the amount of water in the flowers.
Citric acid

Citric acid at 0.25g/l is an effective hydrating solution and stops bacteria growing for short periods, e.g. 1 day (see Section 2.7). There is some evidence that higher concentrations of citric acid, up to 2g/l for either short (12 hours) or long (7 days) periods, improves water uptake and vase life of some flowers e.g. Acacia, Boronia, Eucalyptus, Geleznowia. However, these concentrations damage other flowers, e.g. some roses. The use of high concentrations of citric acid is worth experimenting with as a way of improving water uptake.

Wetting agents

Wetting agents are like detergents and help water move up the flower stem, getting more water in the flower. Wetting agents are worth experimenting with, particularly as postharvest treatments for flowers that will be transported dry for some time, e.g. during export.

Postharvest treatment with wetting agents sometimes improves water uptake, both during the treatment and later, after dry transport.

Each flower requires a different dose and over-doses can cause damage. With Acacia a 16 hour treatment at 2°C to 4°C (or 20°C) with 0.01% Agral 600 (= 0.1ml Agral/l water = 1ml Agral/10l water) greatly improved later flower opening and life. Similar treatments had a small effect on Ozothamnus but no effect on two Leptospernum species. Some Protea growers who have found benefits of wetting agents regularly use them in their flower water. The most commonly recommended wetting agent is Agral®, but Silwet® has also been used with Proteas. A commercial postharvest solution that contains a wetting agent is Chrysal RVB®. A germicide such as a quaternary ammonium compound, or aluminium sulphate (0.2g/l) if the water is pure (not chlorine), is used with wetting agents, and sugar can be combined with them.

Commercial postharvest solutions and flower foods

The following is a list of some of the postharvest solutions and flower foods available commercially in Australia. Florist and flower industry supply companies may have others. See Section 5.18 below for suppliers.

General purpose of postharvest solutions.

- Chrysal Clear Professional #2 processing solution. Chrysal suppliers can recommend which postharvest solution best suits each flower.
- Aquaplus.
- Belpak.
- Ciro.
- “Cut Flower Food and Preservative” (Australian).
- Eurofleur.
- Fleur Vital.
• Flourish (Australia).
• Flower Power.
• Oasis® Floral Preservative.

Commercial germicide solutions:

• Chrysal CVB, chlorine based germicide
• Chrysal OVB, contains quaternary ammonium germicide
• Physan, quaternary ammonium germicide
• Sporekill, quaternary ammonium germicide
• Path-X, quaternary ammonium germicide.

Hydrating solutions:

• Chrysal Clear Professional #1/Chrysal RVB.

High sugar solutions:

• Bud Chrysal AKC.

Flower food, for retailers and consumers:

• Chrysal Clear Professional #3/Vase Solution
• Chrysal Clear Powder Universal Vase solution
• Chrysal Fresh flower food
• Eurofleur
• Flourish (Australia)
• “Cut Flower Food and Preservative” (Australian)
• Belpak
• Oasis® Floral Preservative.

The National Registration Scheme for Agricultural and Veterinary Chemicals

At present the Scheme does not include cut flower preservatives.

5.6 Packing sheds and equipment

Layout in the shed is important as it can save hours of labor.

The shed should be located centrally to the plantation. It needs to be easy for staff to access and for vehicles to bring flowers in from the plantation, to take orders out, and to receive deliveries.

A quick and easy flow of flowers needs to be planned – from the plantation to cleaning and grading, buckets or tanks of water, cold room, pesticide treatments, packaging, cold room and final transport out of the farm.
Size depends on the maximum volume to be handled at any one time and the expected storage time. For operations of 2ha to 4ha, a shed of 20m x 7m x 3m high should serve quite well. A second floor, for stores, cartons etc. maybe efficient.

Sheds should be insulated. Tall trees and shrubs can shade them. Sprinklers can be placed on the roof to cool the roof. Windows should not let hot sun in. Skylights usually let too much heat into the shed.

Sheds need a concrete, non-slip, floor that’s easy to clean. Floor mats, for people to stand on, are important. They need good light, both natural and artificial. They need wide doors.

A packing shed is used for many things. The flowers must be cleaned and graded and then packed. It is ideal to separate the packing from the cleaning and grading. Sheds may also be stores, for cartons and equipment, a cover for the cold room, an office and a staff room. A chemical store should be separated from the general packing shed.

Separate the packing shed from machinery, particularly petrol/diesel driven motors.

Within the shed it helps to have benches of different heights, for different jobs and different staff. Alternatively, the floor height can be raised with wooden platforms. Seats for workers are important. Cartons can be stacked above the packing bench to allow quick packing.

For further information see:
- Cass, Slater, and Tregea (1996)
- AFPGA (2000).

### 5.7 Grading standards

Flowers must be graded to the customer’s requirements. Ask the customer what they want! Write and illustrate your own grading standards.

Some guides, or examples, of standards are given in the following publications.

- Standards Australia (1999) (Draft standards for a range of export flowers).
- Beal, Carson, Turnbull, and Forsberg (2001) (*Ozothamnus*).
- Crothers, Wells and Mahoney (1994) (*Chamelaucium*).
5.8 Agricultural chemicals and pesticides

Advice on agricultural chemicals

The regulation and registration of agricultural chemical use is complex. Different states have different controls, requirements for licences and requirements for training.

Following is a list of contacts for advice on agricultural chemicals:

The National Registration Authority for Agricultural and Veterinary Chemicals (NRA)
Phone: (02) 6272 5158
Fax: (02) 6272 4753
E-mail: nra.contact@nra.gov.au
Internet site: www.nra.gov.au

NSW: Environment Protection Authority, Pesticides Unit
Phone: (02) 9995 5799
or
EPA pesticide officers in Sydney and regional offices

VIC: Chemical Information Service
Phone: (03) 9210 9379
Fax: (03) 9210 9298

SA: Department of Primary Industries
Farm Chemicals program
Phone: (08) 8226 0549

InFINDER, Agrivet chemical information service
Phone: (08) 8226 0405

QLD: Department of Primary Industries, Call Centre
Phone: 13 25 23

WA: Agriculture Western Australia
Phone: (08) 9368 3815

TAS: Dept. of Primary Industry and Fisheries
Mike Norman
E-mail: Mike.Norman@dpiwe.tas.gov.au
Phone: (03) 6233 3565

NT: Department of Primary Industry and Fisheries
Phone: (08) 8999 2272

ACT: Environment ACT
Phone: (02) 6207 9777
Publications and lists of registered agricultural chemicals

- PUBCRIS on NRA’s Internet site: www.nra.gov.au
- IMS Publishing (undated, Agricultural and Veterinary Product Index).
- Infopest (see reference list, Section 7).
- InFINDER, Agrivet chemical information service, Primary Industries and Resources, SA. Phone (08) 8226 0405.
- Peskem, at the Centre for Pesticide Application and Safety, The University of, Queensland, Gatton College. Phone: (07) 5460 1291 They will conduct a search and provide a list of currently registered chemicals and uses for the chosen crop, pest product or active constituent, for a fee.

NRA permits for off-label use, including minor crop use

Inquiries regarding permits may be directed to:

- NRA’s permit evaluators
  Phone: (02) 6272 3216 OR (02) 6272 3726 OR (02) 6271 6347
- NRA’s general
  Phone: (02) 6272 5158

Information about permits, including a list of existing off-label permits, is available from NRA’s Internet site: www.nra.gov.au/permits/permits.shtml

Some NRA publications are:

- NRA fact sheet: Minor Use Program (available on NRA’s Internet site)
- NRA Information sheets: Off-label Permits for Minor and Emergency Uses; and Understanding Off-label Permits (available on NRA’s Internet site)
- permits for Agricultural and Veterinary Chemical Products, available from the Australian Government Publishing Service for a fee.

See the previous two pages for NRA contact details.

A private company that facilitates obtaining NRA permits for off-label uses, for a fee, is:

Crop Protection Approvals Ltd, Level 1, 5 Everage St, Moonee Ponds Vic 3039.
Phone: (03) 8371 0001
Fax: (03) 9375 7552
E-mail: cpa@cpaltd.com.au
Internet: www.cpaltd.com.au
Disposal of agricultural chemicals

Hazardous substances (or “prescribed wastes”, including most pesticides and heavy metal compounds such as silver) should not be disposed of into a sewer, waterway or land fill. They should be disposed of by an accredited/licensed waste contractor with the necessary permits (from EPA in Victoria and NSW), or through a chemical industry disposal program.

Non-hazardous substances can be disposed of via the sewer if the business has a trade waste agreement with the local sewage authority (e.g. Sydney Water Corporation Ltd). They can be disposed by land irrigation as long as this does not pollute surface or ground waters. Check with the EPA or local council to see if a permit is needed.

Occupational health and safety

Workcover authorities or their equivalent in each State, e.g. WorkSafe Victoria and WorkCover Authority, NSW, administer safe use of agricultural chemicals. There are regulations and codes of practice to ensure a safe work place.

For example:

- in Victoria there is a code of practice for: Dangerous Goods Storage and Handling (No. 27, 2000) available from WorkSafe Victoria
- in NSW there is a code of practice for the safe use and storage of chemicals in agriculture available from NSW Workcover Authority, Phone 13 10 50.

For further information on occupational health and safety see 5.16 below.

Further information

For further information on agricultural chemical use, safety and disposal see:

- Steain and Gollnow (2001)
- Flowers Victoria (1998)
- Corry (2000).

5.9 Insecticide fumigation (gassing)

Fumigation of wildflowers

For further information on insecticide fumigation of wildflowers see:

- Seaton (1988)
- Wood and Wood (1991)
- Williams (2000)
Fumigation rooms, equipment and methods

For further information on fumigation rooms:

- Bond
- some suppliers of fumigants/insecticide gases can provide information on insecticide fumigation e.g. BOC Gases, Robert Ryan, Phone (02) 9616 3365
- the ECO₂FUME® (phosphine) and Insectigas®-D labels are very informative
- there are experts in some State departments of agriculture or their equivalent.

Regulation of fumigation rooms and pest controllers

This varies from State to State, but either the State Health department or equivalent and/or the State WorkCover authority or equivalent train and licence fumigators (pest controllers) and regulate the use of fumigation rooms and equipment. This applies to insecticides classified as “Dangerous Poison” such as methyl bromide and phosphine.

For example in Victoria, a pest control business must have trained licensed pest controllers and fumigation rooms that meet the regulations. This process is managed by the Environmental Health group in the Department of Human Resources. If fumigation is done as part of another business, e.g. an export business, no one trains, licences and regulates. However, WorkCover regulates the use of all fumigation rooms from the point of view of occupational health and safety.

In NSW the WorkCover Authority issues licences for operators and regulates the use of all fumigation rooms and equipment.

In other states, ask the Health Department, Workcover or equivalent organisations about the regulation of fumigation rooms, equipment and operators.

Diagram of a 27 cubic meter, commercial fumigation chamber used in disinfestation experiments, showing the outline of the chamber, the fumigant supply, and the movement of hot air for heating (From Williams 2000).
Methyl Bromide

Methyl bromide is likely to be banned by 2005 for all pre-transport treatments except those required by a government, e.g. an importing government that requires no live insects such as Japan. It also is likely to become less available and more expensive.

5.10 Packaging

Costs

Cartons are expensive, particularly if they only make one trip. To reduce costs consider the following suggestions.

- Use big cartons where the market or buyers accept this. Make sure the cartons are strong enough to protect the flower and the mass of flowers doesn’t overheat.
- Use plain, unprinted, simple cartons.
• Buy cartons in bulk.
• Re-use cartons, as long as this doesn’t spread disease.
• Use returnable, collapsible cartons.
• Use other reusable containers, e.g. buckets.

**Special packaging**

There are some returnable, collapsible, reusable cartons available.

Some cartons can hold water, or a bucket of water, in the base, to enable transport with stems in water.

Amcor’s Barriercote cartons have a layer of plastic sandwiched between the cardboard layers. This maintains high humidity and strength in the cartons and is recyclable.

Lightly waxed cartons reduce water loss. They are strong, but are expensive. They cannot be recycled, so some markets do not accept them e.g. many European markets, and many Australian supermarkets.

Insulated packaging is available, to help keep cold flowers cold. These can be special cartons, or polystyrene boxes. However, unless the flowers are packed cold and the packages are kept cold, the risk of the flowers overheating in these closed packages is great.

Modified atmosphere packaging keeps the flowers in a sealed bag or box and as a result, the flowers use up the oxygen in the package and release carbon dioxide into it. This different atmosphere may keep some flowers looking better for longer. However, this method only works well if the flowers and environment are cold all the time, a situation that is not common in Australian handling chains. The high humidity increases fungal growth if rots are present and the flowers are not kept cold.

Ethylene absorbing bags, carton liners and sachets were discussed in Section 5.4. A reference book on fibreboard cartons is Wright, McKinlay and Shaw, (1992).

### 5.11 Long term cold storage and sea freight

Long term storage and shipping of flowers is a good way to lengthen the marketing period, accumulate flowers for peak sales periods and as an alternative to costly and sometimes scarce air freight.

Some Australian native flowers and related *Proteaceae* can be stored successfully for 1 to 4 weeks without losing too much quality and vase life, as long as the pre-treatment, storage and after-storage treatments are done properly.

For long term storage or shipping, flowers need to be held dry. Follow this method.

• Don’t store flowers that are infected with Botrytis.
To protect against Botrytis growth, dip in a registered fungicide where this use is registered and approved.

Dry the flowers, either as they stand in water to cool, or by shaking the flowers.

Hold the flowers with their stems in germicide, hydrating solution or commercial postharvest solutions at 2°C to 4°C overnight, to take up water and to cool.

Pack in the cold room so that the flowers don’t heat up. If this is not possible pack very quickly (in a few minutes) under cool conditions.

Pack flowers tightly into a carton lined with a plastic bag, with a layer of paper (newspaper or butchers’ paper) lining the bag. Tightly seal the bag (to get rid of as much air as possible) with a cable tie.

Get the storage temperature as close to 0°C as possible without any risk of freezing, so the thermostat may be set on 1°C and the temperature will range from 0°C to 2°C.

Avoid storing ethylene sensitive flowers with ethylene producing fruit (apples, pears, melons, stone fruit, tomatoes and bananas).

At the end of storage, remove flowers from the packaging. Recut the stems and place in a hydrating solution or commercial postharvest solution. Do this in a cold room, with a cover (e.g. plastic shroud) over the flowers to prevent them from drying out until they have taken up water from the solution.

Some examples of vase life before and after storage are given in the table shown on the next page. Others are given on the species pages in Section 4.
The effects of 4 weeks dry cold storage on vase life of selected flowers

Storage was at 0°C to 2°C. Vase life (days) was at 20°C. Pre-storage treatments varied.

<table>
<thead>
<tr>
<th>Species</th>
<th>Vase life - fresh</th>
<th>Vase life - stored</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anigozanthos:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gold Fever</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pulcherrimus</td>
<td>14</td>
<td>4</td>
<td>All had fungal infections after storage. None were treated with postharvest sugar solutions.</td>
</tr>
<tr>
<td>Bush Harmony</td>
<td>12</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Bush Haze</td>
<td>7</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Ruby Delight</td>
<td>7</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Banksia prionotes</td>
<td>14</td>
<td>7</td>
<td>If the flowers were stored in sleeves or liners, instead of closed plastic bags, vase life was only 2 days</td>
</tr>
<tr>
<td>Blandfordia grandiflora</td>
<td>up to 7 days</td>
<td></td>
<td>Vase life after 30 days storage varied between different harvests and different growing conditions. Botrytis can be a problem – apply postharvest fungicides where they are approved.</td>
</tr>
<tr>
<td>Caustis blakei</td>
<td></td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Chamelaucium:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alba</td>
<td>8</td>
<td>1</td>
<td>Botrytis infection caused short vase life, despite postharvest fungicide treatment.</td>
</tr>
<tr>
<td>Purple Pride</td>
<td>9</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Eucalyptus foliage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. cinerea</td>
<td>9</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>E. crenulata</td>
<td>9</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Leucadendron</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silvan Red</td>
<td>28</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Leucospernum:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cordifolium</td>
<td>11</td>
<td>4</td>
<td>Fungal infection was a problem on L. cordifolium</td>
</tr>
<tr>
<td>Firewheel</td>
<td>10</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Protea:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cynaroides</td>
<td>8</td>
<td>6</td>
<td>Leaf blackening was a problem in P. neriifolia.</td>
</tr>
<tr>
<td>neriifolia</td>
<td>7</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Telopea speciosissima</td>
<td>8</td>
<td>6 to 8</td>
<td></td>
</tr>
<tr>
<td>Thryptomene calycina</td>
<td>7</td>
<td>7</td>
<td>Some flower drop occurred during storage</td>
</tr>
</tbody>
</table>

It is clear that only the Banksia, Caustis, Eucalyptus foliage, Leucadendron and maybe the Telopea and Thryptomene could be stored for 4 weeks and still have a vase life of 7 days.
South African research found that the following species could be stored for 3 weeks and still have a vase life of 2 to 3 weeks in flower food/vase solution: Protea compacta, P. obtusifolia, P longiflora, P. cynaroides, P. barbigera, P. grandiceps, P. eximia, Leucospermum nutans, L. lineare and Serruria florida. (Ireland, Meynhardt and Strauss 1967). However, a Protea grower points out that in storage, Protea flowers lose their fresh look and fade!

An important advantage of sea freight is that the flowers are cold for the whole trip, and if transport times are short e.g. 2 weeks there may be little loss of quality and vase life compared with air freight.

However, sea freight has four serious drawbacks.

• The time it takes e.g. 3 or 4 weeks to Japan, 4 or 5 weeks to the west coast of USA.
• The huge number of flowers in a 6m long container of 24 cubic meters volume – these need to be accumulated by the exporter and sold by the importer.
• The difficulty in getting good, even, temperature control with all flowers between 0°C and 2°C in a full 6m container. Loss of quality increases greatly if flowers are held at 4°C instead of 0°C to 2°C.
• The fact that most markets discount prices if they know flowers have been sea freighted.

For further information see:

• Jones and Faragher (1991)
• Jones and Allen (1994)
• Ireland, Meynhardt and Strauss (1967).

5.12 The export process

Export is a long, complex process requiring a range of special skills, knowledge and contacts. It is best done by experienced professionals.

It is a risky business as many things can happen once the flowers are out of the control of the growers or exporters. To reduce the risks, a grower needs to work with a capable exporter whom they trust. The exporter must, in turn, work with capable freight forwarders, airlines and importers whom they trust.

The process includes the following steps.

• Grower supplying flowers to meet exporter's requirements e.g. stem length, quality, packaging; applying postharvest treatment and pest and disease control if required.
• Grower providing the necessary documentation: invoice, list of flower types, length, number and price, how many boxes, who the flowers are going to, who they are from.
• Exporter cooling, treating, fumigating flowers if necessary.
- Grower/exporter packing to meet orders. Packaging must meet the requirements of the importing country e.g. holes to allow fumigation/gassing with methyl bromide in Japan, if necessary.
- AQIS completing export inspection and issuing Phytosanitary certificate if required. This is required for Japan and some European countries but not all countries, e.g. not USA at present.
- Environment Australia issuing exporters with a permit to export Australian native flowers.
- Exporter collecting/providing necessary documentation e.g. Phytosanitary certificate; invoice; export permit; a copy of the import permit for some countries.
- Exporter arranging freight forwarder, airline, insurance, air freight.
- Inspection upon arrival in importing country.
- Fumigation if necessary.
- Transport to importer or auction.
- Resale to wholesaler and/or retailer.
- Exporter communicating with importers: what prices were received, what the exchange rate was, what the market was like (over or under supplied), any pest problems or need for fumigation.
- Exporter communicating with growers.

The requirements of the market country need to be understood, including whether:

- Any flowers are forbidden, e.g. flowers from the family Rutaceae, including *Boronia* species, cannot be exported to USA.
- There are pest and disease control requirements.
- Insecticide residues are a problem.
- Phytosanitary certificates or inspection are required.
- Any other documentation is required.
- Import permits are required.
- Import duties are charged.
- There are any requirements for packages e.g., Japan wants packages to have holes in them so they can be fumigated if necessary.
- Fumigation / gassing with methyl bromide occurs in the importing country and if Australian exporters have a say in whether the flowers are fumigated or destroyed.

This information can often be obtained from: the exporter, the importer, the embassy or consulate of the importing country, AQIS or Austrade.

**Export permits and authorities**

Export of all Australian native plant material, including flowers and foliage, is regulated through the Commonwealth Wildlife Protection Act. An Environment Australia permit or authority must be issued before export. Permits are valid for six months. Authorities are multiple-use permits and valid for 12 months.
For information about export permits and authorities contact:

- Environment Australia. GPO Box 636 Canberra ACT 2601, Phone: (02) 6250 0300
- or The Manager, Wildlife Permits and Enforcement, Environment Australia (02) 6274 2752
- or see the Environment Australia Internet site: www.ea.gov.au/biodiversity/trade-use/permits/index.html

The Flower Export Council of Australia can provide good advice on these issues to their members.

**AQIS**

For information about AQIS inspection procedures, Phytosanitary Certificates and the costs of inspections contact state AQIS offices. AQIS have a quality assurance scheme called “Compliance Directives” that allows exporters to take more responsibility for the pest and disease control on their flower and reduces the requirement for AQIS inspections.

AQIS are found on the Internet site: www.affa.gov.au

**Costs of export**

Some of the costs involved once the flowers leave the growers are for:

- exporter’s requirements/obligations (e.g. grading, packing, fumigation, packaging, inspection and Phytosanitary certificate, labor and profit)
- transport, freight forwarder
- air freight
- import duties/tariffs in some countries
- fumigation/gassing with methyl bromide
- transport in importing country
- importing agent and auction fees.

Details of the costs of export are given in several publications: Karingal (1997), Considine and Growns (1998), AFPGA export Workshop video (AFPGA 1998), FECA (1997). However, don’t rely on these estimates. Work out your own costs.

This is an example of the breakdown in costs:

- gross sale price in importing country = 100 units
- costs in importing country = 25-33 units
- freight = 20-33 units
- exporter costs = 10-20 units
- return to growers = 14-45 units.
If the sale price goes down (e.g. due to low market, poor quality or short stems), the costs remain the same and the return to growers goes down.

On average, the costs of exporting flowers are 2 to 3 times the cost of production to the farm gate.

For more information on exporting

- FECA (1997)
- AFPGA (1998)
- Chew, Hunt-Sharman and Morgan (1998)
- Hayes, Jolly, Morris and Rodgers (2000)
- FECA (Flower Export Council of Australia)
  Phone: (03) 9258 6150
  Internet: www.feca.org.au
- Austrade offices in Australia and market countries around the world.

5.13 Vase life: standard conditions for measuring vase life

It’s important to measure vase life of fresh flowers and vase life after trial or mock marketing or export. The standard conditions for measuring vase life, recommended by Reid and Kofranek (1980) are as follows.

- Test about 10 stems of each group of flowers.
- Use clean vases or containers, preferably with one stem per container.
- Use distilled water or deionised water that has been finely filtered to remove microorganisms and particles; clean rain water could be used.
- Have temperature between 18°C and 22°C and humidity of 60% to 70% RH.
- Use cool white fluorescent lights, 1000 lux, (bright room or office lighting) with a 12 hour day (light) and 12 hour night (dark).
- Ventilate the room with an air change every 2 hours.
- Keep air movement at not more than 0.5m/seconds, e.g. the leaves and flowers should not be moving in the wind!

The end of vase life is usually taken to be when a flower becomes unattractive – when it would be thrown out. This is usually when flowers have wilted, dried out, dropped or become an unpleasant color.

It is important to keep good records of when the flowers’ vase life ended. The life of individual flowers can be recorded and then an average worked out. It may be useful to take and keep photographs of how flowers look when fresh, or after mock export and after some days e.g. 7 days.

If it’s not possible to measure vase life under these exact conditions, it is still worth doing it. Try to use the same conditions each time and keep a record of at least the temperature, light, humidity and air movement.

Holding flowers in tightly packed cartons at 15°C for 3 or 4 days can resemble export.
5.14 Drying, dyeing and preserving

For information on drying, dyeing, bleaching and preserving see the following:

- Dubois (1990)
- Dubois and Joyce (1988)
- Dubois and Joyce (1989a)
- Dubois and Joyce (1989b)
- Joyce (1997)
- Herschbach and Stevens (1999)
- Johnston, Joyce, Bhandari, Moncada and Vuthapanich (1999)
- Johnston, Fuss, Murphy, Moncada, Joyce and Bhandari (2000).

5.15 Quality assurance

Quality Assurance (QA) is the term given to all the planned steps taken to ensure that flowers have a consistently good quality that meets the requirements of the buyers.

The benefits of QA, according to those who use it, are:

- good quality
- good sales
- happy customers
- cost savings
- good records
- well trained staff.

In the future, electronic buying and selling (E-commerce) is likely to grow. It will most likely require a good quality assurance and product description system so buyers can buy with confidence.

QA can involve the following steps:

- Some basic quality management practices are documented so all staff know what is required. For example:
  - grading and bunching standards (for particular buyers)
  - product descriptions (e.g. in photos)
  - making and using postharvest solutions including STS
  - cleaning and hygiene
  - measuring temperature in cold rooms.

- Good records are kept. For example:
  - the number of bunches of each length and grade packed from a certain block, or on a certain day
  - postharvest treatments used
  - cold room temperatures

See Work Sheets in Section 6 for examples of record sheets.
• Hazards that would reduce the quality of flowers are identified. For example:
  – *Botrytis* present on sensitive flowers
  – too long between picking and placing in water and cooling
  – STS not active or not applied properly
  – cold room not cold enough
  – flowers kept for too long before they are sold.

• Procedures for dealing with hazards are documented. For example:
  – spray and dip against *Botrytis*
  – flowers are taken to the packing shed more quickly
  – the cold room temperature is lowered
  – STS treatment methods are improved and the treated flowers are regularly
    checked to see that they are protected against ethylene
  – cold room temperature is lowered
  – flowers are sold within 2 days of picking

• The quality of the flowers is checked by keeping some, simulating marketing and
  then seeing what the quality and vase life are.

Some model QA manuals have been written for flowers and while they may be too
detailed for some people, they provide guidance on ways to improve quality
management and a range of check lists. Model manuals include:

• Crothers, Wells and Mahoney (1994) (Queensland Wax and Native Flower
  Association, Waxflower Handbook)
• Mennie (1996) (Model Quality Assurance System for Native Flower Producers)

There are several national and international Quality Assurance systems used in
horticulture. These include:

• AQIS Compliance Directives. For further information contact AQIS export staff in
  State offices or Canberra.
• ISO 9001:2000 (International Organisation for Standardisation). For information
  contact Standards Australia phone (02) 8206 6000, Internet:
• SQF 1000 and 2000. For further information contact: SGS Australasia, Phone:
  (02) 9930 5900, E-mail: sgs_australasia@sgs.com, Internet:

For further information on QA:

• Several views on quality assurance are reported in the Proceedings of the 5th
• Growns (1996).
• The Competitive Edge: How to make quality systems work for you. Horticultural
  Research & Development Corporation (undated).
5.16 Occupational health and safety

Occupational health and safety (OHS) in workplaces is extremely important from the common sense, legal and financial points of view. OHS is regulated and administered by State Workcover authorities or their equivalents. It is the responsibility of employers, employees and suppliers to meet the OHS regulations. The Workcover authorities provide advice and information and can inspect and prosecute. Codes of practice provide guidance on ways to comply with the regulations.

For further information:

- Contact your State Workcover authority or equivalent.
- “Getting started with workplace health and safety” booklets, from WorkSafe Victoria.
- “Health and safety. The best investment for small business” (WorkSafe Victoria).
- Code of practice for the safe use and storage of chemicals in agriculture (NSW WorkCover Authority).

5.17 Cost and benefits of postharvest treatments

Financial benefits of postharvest treatments

The following financial benefits are likely to result from postharvest treatments.

- Reduced losses due to wilting, flower drop and poor flower opening at each step in the handling chain. One estimate of the net saving is at least $10 per $1,000 of sales at the handling step where the treatments are applied, e.g. at the growers (Staby, 1994).
- Reduced losses from rejections or claims by buyers.
- Less risk of fumigation costs (e.g. $750 per consignment in Japan) or of total destruction in an importing country.
- Less risk of damage due to ethylene, e.g. Chamelaucium with noticeable flower drop has a market value of between 0 and 10% that of good Chamelaucium.
- A secure market – importers overseas don’t want to buy flowers from Australia that have not had proper postharvest treatments.
- Increased sales as a result of customer satisfaction.
- Increased sales as a result of promoting the flowers as high quality and having long life. The long life of the flowers can even be guaranteed – something the supermarkets in Australia and overseas want to do.
- Savings in labor and time because there are fewer problems to deal with (poor quality flowers, rejections/claims, fumigation, and complaints) if postharvest treatments are used correctly.

“A little extra trouble can return handsome dividends to the grower as a recognised supplier of high quality products” (Bottomley and Smee 1992).
Costs of postharvest treatments

Following is a summary of the costs of production, picking, postharvest treatments, packaging and transport, mostly for *Chamelaucium*. The costs were taken from three publications: Considine and Growns (1998); FECA (1997); and AFPGA (1998).

- Production: 5c/stem.
- Picking: 5c/stem.
- Grading, bunching, postharvest treatments, fumigation and packing: 2c to 4c/stem.
- Cartons: 1.7c to 2.2c/stem.
- Transport to market or exporter: 2c to 9.7c/stem depending on the distance and method of transport.

For export costs – see 5.12 above

For several other flowers, the picking, grading, treatment and carton costs are around 25% higher than those quoted above (see Hyde 1998, Carson 2000).

For larger flowers, costs per stem are greater, e.g. for *Protea cynaroides* (king protea) picking and packing may be 50c/stem, cartons 50c/stem and transport 15c/stem (Tranter 1998).

The greatest postharvest cost is labor. The cost of the ingredients of postharvest solutions is very small. Some examples of postharvest solution costs follow. They are under-estimates, conservatively based on 50 stems in 4l of solution in a 20l bucket, with the solution used only once. In practice more or fewer stems may be used, less solution may be used and the solutions may be re-used. The makers of commercial solutions recommend that they be reused, in some cases for up to 7 days.

- Chlorine and bromine germicides, approx. 1c to 2c/100 stems.
- Quaternary ammonium germicides approx. 4c/100 stems.
- Citric acid approx 2c/100 stems.
- Aluminium sulphate approx. 1c/100 stems.
- Commercial postharvest solutions approx 12c to 90c/100 stems.
- STS approx. 10c to 12c/100 stems.
- 1-MCP (EthylBloc) is predicted to be slightly more expensive than STS per stem, but the disposal cost will be negligible.
- Flower food treatments at the florist are estimated to cost $3.45 per $1,000 of sales, with a net benefit of at least $10 per $1,000 of sales.

5.18 Sources and suppliers of postharvest chemicals, solutions and equipment

Included below is information on some suppliers and sources of some anti-ethylene treatments, postharvest chemicals, postharvest solutions and equipment.

This list does not include information on all products or all suppliers. No endorsement of the named products or suppliers is intended, nor is criticism implied of similar products or suppliers that are not mentioned.
For many things like cold rooms, refrigeration engineers and contractors, thermometers, humidity meters, cartons, packaging, industrial and laboratory chemicals, laboratory equipment, refer to the Flower Register or Yellow Pages. The Flower Register Australia is published annually by Rural Press Magazines
Phone: (03) 9287 0900 or 1800 061 022.

Some useful categories in the Yellow Pages include:

- Agricultural machinery
- Boxes & Cartons
- Carriers – light
- Chemicals, agricultural
- Chemicals, industrial
- Chemical suppliers
- Cool room builders &/or designers
- Farm equipment and supplies
- Florists’ supplies
- Industrial and protective clothing
- Insecticides herbicides and fungicides
- Instruments – scientific
- Laboratory equipment &/or supplies
- Packaging materials
- Pest control
- Scales and weighing equipment
- Thermometers
- Transport services
- Waste reduction & disposal services.

**Anti-ethylene treatments**

**Chrysal AVB**

Chrysal AVB is available in Australia through Chrysal suppliers:

- Clearpac, 4 Rocco Dve Scoresby, Vic. Phone: (03) 9764 8255 and Shops 4 and 5 National Flower Centre, 542 Footscray Rd, Footscray, Vic. E-mail: clearpac@ozemail.com.au
- Hortraco Pty Ltd, 12B/8 Gladstone Rd, Castle Hill, NSW Phone: (02) 9899 3232
- L&G Florist Supplies, 107-109 Parramatta Rd, Granville, NSW Phone: (02) 9637 1775
- A&L Florist Supplies, 1336 The Horsley Drv Bossley Park, NSW Phone (02) 9610 7726
- Flowerpack, 23 Kensington St., E. Perth, WA Phone: (08) 9325 3955 Fax: (08) 9325 2847
STS stock solutions

Daly Laboratories Pty Ltd, Brian Banovich,
32 Railway Pde Welshpool WA 6106
Phone: (08) 9358 5445
Fax: (08) 9358 5440
E-mail: dalylabs@nw.com.au

STS ingredients

Silver nitrate and sodium thiosulphate (either anhydrous or pentahydrate) are available from laboratory or industrial chemical suppliers. Check a few suppliers to get the best price.

1-MCP

1-MCP is made by Rohm & Haas in USA and sold as EthylBloc®. It is not yet available in Australia but probably will be soon. Further information can be obtained from:

- Rohm Haas Melbourne (03) 9272 4283
- Rohm Haas USA, Gerald Kollman, 727 Norristown Road, Spring House, PA 19477-0904, USA
  Phone + 1-215-619 5534
  Fax + 1-215- 619 1614
  E-mail: GKollman@rohmhaas.com
- EthylBloc® Internet site: http://www.ethylbloc.com/

Ethylene absorbing materials

- Bloomfresh : Ausdel
  Phone: (03) 9585 1277
- Ethylene Control Products: PMG International Pty Ltd
  Phone: (08) 9242 1288
  Fax: (08) 9242 1599

- Ethysorb: Molecular Products Ltd
  Mill End, Thaxted, Essex, CM6 2LT, England
  Phone: + 44-1371-830676
Postharvest chemicals

Germicides

Chlorine and chlorine-bromine products: Pool and spa shops, supermarkets, and suppliers of horticultural disinfectants, e.g. Wobolea Phone: (03) 9768 2533

Quaternary ammonium compounds e.g. benzalkonium chloride: Pool and spa shops, supermarkets, and nursery suppliers.

Physan: Maril Products, Inc., 320 West 6th Street, Tustin, CA 92780 USA, Phone: +1-714-544-7711
Fax: +1-714-544-4830
E-mail: physan@earthlink.net

Aluminium sulphate: Water cleaning products from pool shops, laboratory suppliers.

Equipment for automatically delivering germicides to buckets or tanks and chlorine and bromine test strips, Wobolea Phone: (03) 9768 2533.

Hydrating solutions

Citric acid is available from:

- Industrial chemical suppliers, e.g. Redox, APS, Spectrum, at $5 to $8/kg, but only in 25kg to 50kg lots.
- Health food shops have 1kg packs for around $11.
- Supermarkets have 75g packs for $1.65.
- Laboratory suppliers are more expensive.

Aluminium sulphate: Water cleaning products from pool shops, laboratory suppliers.

Agral 600: Crop Care Australia, agricultural chemical suppliers.
Commercial postharvest solutions and flower food

Chrysal products:
- Clearpac, 4 Rocco Dve Scoresby, Vic.
  Phone: (03) 9764 8255 and
  Shops 4 and 5 National Flower Centre, 542 Footscray Rd, Footscray, Vic.
  E-mail: clearpac@ozemail.com.au
- Hortraco Pty Ltd, 12B/8 Gladstone Rd, Castle Hill, NSW
  Phone: (02) 9899 3232
  Internet: www.flowerpack.citysearch.com.au
- L&G Florist Supplies, 107-109 Parramatta Rd, Granville, NSW
  Phone: (02) 9637 1775
- A&L Florist Supplies, 1336 The Horsley Drv Bossley Park, NSW
  Phone: (02) 9610 7726
- Flowerpack, 23 Kensington St., E. Perth, WA
  Phone: (08) 9325 3955
  Fax: (08) 9325 2847
- A&T International Pty Ltd, 7/43 Button St Osborne Park, WA
  Phone: (08) 9446 5522
- Florists’ Suppliers Pty Ltd, 1 Marrow Rd Keswick, SA
  Phone: (08) 8293 5544
- Tony’s & Penfields Wholesale Flowers, 12-18 Daringa St Mile End, SA
  Phone: (08) 8234 0094
- Garden Nursery Products, 35 Old Pacific Hwy Yatala, Qld
  Phone: (07) 3287 4808
- Florist Accessories, 24 Manilla St E Brisbane, Qld
  Phone: (07) 3391 8044

Chrysal suppliers also sell equipment for automatically delivering postharvest solutions to buckets or tanks.

Aquaplus: Temples Florist Sundries, 55 Vore St., Silverwater, NSW, 2141.
  Phone: (02) 9748 2666.
  FREECALL: 1800 815 194
  Fax: (02) 9748 2662

Belpak: Belpak Australia, Mr Les Nicholson
  Phone: (03) 5985 7526

Ciro: Zwapak Australia Pty Ltd, 12 Sherson Cres., Mentone, Vic.
  Phone: (03) 9585 3499
  Fax: (03) 9585 3905
  E-mail: zwapak@smart.net.au
  Internet: www.zwapak.com

“Cut Flower Food and Preservative” (Australian): L&G Florist Supplies
  107-109 Parramatta Rd Granville NSW 2142
  Phone (02) 9637 1775
Eurofleur: Zwapak Australia Pty Ltd, 12 Sherson Cres., Mentone, Vic.
Phone: (03) 9585 3499
Fax: (03) 9585 3905
E-mail: zwapak@smart.net.au
Internet: www.zwapak.com

Fleur Vital: Temples Florist Sundries, 55 Vore St., Silverwater, NSW, 2141. Phone: (02) 9748 2666
FREE CALL: 1800 815 194
Fax: (02) 9748 2662

Flourish Australia: Flourish Australia
Phone: (03) 9738 1980, or 1800 356 874

Flower Power: Wobolea
Phone: (03) 9768 2533

Oasis® Floral Preservative: “From leading florists’ suppliers” – see list below.
Flos, Flower Life Support System, sachets.
Phone: (02) 6584 6123

**Equipment for automatically delivering postharvest solutions to buckets or tanks**

Wobolea, Phone (03) 9768 2533

Chrysal suppliers – see above.

**Fumigants, fumigation equipment and fumigation services**

- BOC Gases, Robert Ryan
  Phone: (02) 9616 3365
- Some pest control companies provide methyl bromide fumigation (see under Pest Control in Yellow Pages).

**Gel-ice packs**

- Drypac
  Phone (03) 5622 3179

**Insulating materials, blankets, pallet covers**

- Sancell
  Phone (03) 9587 2199
- Omega (NZ)
  Phone + 64 9274 9923
Temperature loggers

There are many companies that sell loggers. A short list of companies with horticultural experience is:

- Hastings Data Loggers
  Phone: 1800 243 282
  Internet: www.hdl.com.au
- Cox Temperature Recorders
  Phone: (03) 9651 5135
  Internet: www.coxrecorders.com.au
- Temperature Technology
  Phone: (08) 8231 1266
- R&H Wholesale
  Phone: (08) 8354 0100
- PMG International
  Phone: 0419 988 930
- ISOPAR
  Phone: 0418 902 724
## 6. Work sheets, check lists

### Work sheet 1. Harvest record

<table>
<thead>
<tr>
<th>Date</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30/12</td>
</tr>
<tr>
<td>Time picked</td>
<td>9am</td>
</tr>
<tr>
<td>Variety</td>
<td>Cordi</td>
</tr>
<tr>
<td>Block/row</td>
<td>A6</td>
</tr>
<tr>
<td>Stems picked number</td>
<td>1,200</td>
</tr>
<tr>
<td>Time delivered to packing shed</td>
<td>9.30am cold room 2</td>
</tr>
<tr>
<td>Weather: Note any extreme conditions in last 24 hours</td>
<td>40°C on 29/12</td>
</tr>
<tr>
<td>Comments</td>
<td>some wrong shape</td>
</tr>
<tr>
<td>Signature</td>
<td>JF</td>
</tr>
</tbody>
</table>
### Work sheet 2. Grading and packing records

<table>
<thead>
<tr>
<th>Date</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30/12</td>
</tr>
<tr>
<td>Variety</td>
<td>Cordi</td>
</tr>
<tr>
<td>Block or ID</td>
<td>A6</td>
</tr>
<tr>
<td>Stems picked</td>
<td>1,200</td>
</tr>
<tr>
<td>Number of stems packed, by length</td>
<td>40cm</td>
</tr>
<tr>
<td></td>
<td>50cm</td>
</tr>
<tr>
<td></td>
<td>60cm</td>
</tr>
<tr>
<td>Total stems packed</td>
<td>1,000</td>
</tr>
<tr>
<td>Main reasons for rejection</td>
<td>Wrong shape</td>
</tr>
<tr>
<td>Comments</td>
<td></td>
</tr>
<tr>
<td>Signature</td>
<td>JF</td>
</tr>
</tbody>
</table>
## Work sheet 3. STS treatment records

<table>
<thead>
<tr>
<th>Date</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30/12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flower variety</th>
<th>Purple wax</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>STS - Concentration of the treatment solution (mM)</th>
<th>0.2</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>When was solution made up?</th>
<th>30/12</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>When was solution tested for activity?</th>
<th>Wasn't!</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Treatment temperature (°C)</th>
<th>2°C cold room 2</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Treatment length (minutes or hours)</th>
<th>16 hours</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Treatment start time</th>
<th>5pm 30/12</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Treatment finish time</th>
<th>9am 31/12</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Measured uptake ml/400g bunch</th>
<th>250ml OK!</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Comments e.g. Humidity? Air movement?</th>
<th>Air movement low</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Signature</th>
<th>JF</th>
</tr>
</thead>
</table>
### Work sheet 4. Calculating STS uptake

<table>
<thead>
<tr>
<th>Date</th>
<th>Flower:</th>
<th>Bunch weight (eg 400g):</th>
<th>Bunches per bucket (e.g. 10):</th>
<th>STS concentration (e.g. 4mM):</th>
<th>Temperature:</th>
<th>Treatment time:</th>
<th>Target STS uptake (e.g. 10g to 50g per 400g bunch):</th>
<th>Humidity:</th>
<th>Air movement:</th>
<th>Other comments:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Example</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30/12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bucket 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Example</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bucket 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bucket 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Uptake (g per bucket)

- Bucket 1: 120 g
- Bucket 2: 200 g
- Bucket 3: 200 g

\[ \text{Uptake (g per bucket)} = \frac{520}{3} = 171 \]

#### Uptake (g per 400g bunch)

-Bucket 1: 120 g
-Bucket 2: 200 g
-Bucket 3: 200 g

\[ \text{Uptake (g per 400g bunch)} = 17 \text{ (with 10 bunches per bucket)} \]

<table>
<thead>
<tr>
<th>Signature</th>
<th>JF</th>
</tr>
</thead>
</table>

---

**Example**

<table>
<thead>
<tr>
<th>Date</th>
<th>Before treatment weight (1) in g</th>
<th>After treatment weight (2) in g</th>
<th>Uptake (1) minus (2)</th>
<th>Date</th>
<th>Before treatment weight (1) in g</th>
<th>After treatment weight (2) in g</th>
<th>Uptake (1) minus (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30/12</td>
<td>2,500</td>
<td>2,380</td>
<td>120</td>
<td>30/12</td>
<td>2,600</td>
<td>2,400</td>
<td>200</td>
</tr>
<tr>
<td>30/12</td>
<td>2,600</td>
<td>2,400</td>
<td>200</td>
<td>30/12</td>
<td>2,700</td>
<td>2,500</td>
<td>200</td>
</tr>
</tbody>
</table>

**Average**

\[ \text{Uptake (g per bucket)} = \frac{520}{3} = 171 \]

\[ \text{Uptake (g per 400g bunch)} = 17 \text{ (with 10 bunches per bucket)} \]
Work sheet 5. Insect fumigation records

<table>
<thead>
<tr>
<th>Date</th>
<th>Example 30/12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety</td>
<td>Cordi</td>
</tr>
<tr>
<td>Insecticide used</td>
<td>ECO₂FUME® (batch abcd)</td>
</tr>
<tr>
<td>Batch no.</td>
<td></td>
</tr>
<tr>
<td>Rate</td>
<td>50g/m³ (label rate)</td>
</tr>
<tr>
<td>Temperature of fumigation room (°C)</td>
<td>15</td>
</tr>
<tr>
<td>Fumigation start time</td>
<td>5pm 30/12</td>
</tr>
<tr>
<td>Fumigation finish time</td>
<td>8am 31/12 (15 hours)</td>
</tr>
<tr>
<td>Quality check</td>
<td>OK</td>
</tr>
<tr>
<td>Comments</td>
<td></td>
</tr>
<tr>
<td>Signature</td>
<td>BG</td>
</tr>
</tbody>
</table>
**Work sheet 6. Flower treatment check-list**

**This list can be used:**
1. By the grower/packer/exporter to check that the necessary treatments have been applied to their own flowers.
2. To send to the buyer to tell them what has been done to the flowers and what needs to be done.

| Date: .......................................................... | Grower: ........................................................................................................... |
| Variety: .................................................................. | I.D.: .................................................................................................................. |

**The flowers have been:**

| Picked (date): ........................................ | Cooled to (°C): ............................................................................................... |

**Treated with:**

- Germicide [ ]
- Hydrating solution [ ]
- Commercial solution [ ]
- STS/commercial silver solutions [ ]
- 1-MCP/ EthylBloc® [ ]
- Fumigation with insecticide [ ]

**Flowers left the packing shed:**

| Name of transport/carrier: ........................ | Time: .................................................................................................................. |
| Comments: ........................................................ | Name of person responsible: ............................................................................. |

| .......................... | .......................................................... | Signature: ............................................................................................................. |
### Work sheet 7. Flower treatment check-list – alternative format

**This list can be used in two ways:**
1. By the grower/packer/exporter to check that the necessary treatments have been applied to their own flowers.
2. To send to the buyer to tell them what has been done to the flowers and what needs to be done.

Date: ..........................................................................  Grower: ..............................................................................................

Variety: ..........................................................................  I.D.: ..............................................................................................

**Treatment(s) received by flowers:**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Check</th>
<th>Initials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Picking date</td>
<td>e.g. 30/12</td>
<td>e.g. JF</td>
</tr>
<tr>
<td>Cooled to (°C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germicide</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrating solution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial postharvest solution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STS/commercial silver solutions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-MCP/ EthylBloc®</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insecticide fumigation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport/carrier:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Departure time:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**On arrival these flowers need:**

- Re-cooling
- Cut stems, place in water
- Postharvest solutions
- Fumigation
- STS/1-MCP/ EthylBloc®

Name of person responsible: ........................................

Signature: ................................................................

Comments:......................................................................................................................................................

.................................................................................................................................................................

.................................................................................................................................................................
**Worksheet 8. Cold room temperature and humidity records**

Use one sheet for each cold room.

Cold room no…………………………………………………………………………

<table>
<thead>
<tr>
<th>Date</th>
<th>Example 30/12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>9am</td>
</tr>
<tr>
<td>Thermometer 1 (°C)</td>
<td>3</td>
</tr>
<tr>
<td>Thermometer 2 (°C)</td>
<td>2</td>
</tr>
<tr>
<td>Humidity (%)</td>
<td>70</td>
</tr>
<tr>
<td>Comments</td>
<td>OK</td>
</tr>
<tr>
<td>Signature</td>
<td>JF</td>
</tr>
</tbody>
</table>
### Work sheet 9. Cleaning check list

<table>
<thead>
<tr>
<th>Date cleaning done</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Example 30/12</strong></td>
<td></td>
</tr>
<tr>
<td>Picking trailer, trolley or barrow</td>
<td>JF</td>
</tr>
<tr>
<td>Buckets, water containers</td>
<td></td>
</tr>
<tr>
<td>Benches</td>
<td></td>
</tr>
<tr>
<td>Floor</td>
<td></td>
</tr>
<tr>
<td>Equipment</td>
<td></td>
</tr>
<tr>
<td>Cold room</td>
<td></td>
</tr>
<tr>
<td>Store room – General</td>
<td></td>
</tr>
<tr>
<td>Store room – Chemical</td>
<td></td>
</tr>
<tr>
<td>Remove waste from shed</td>
<td></td>
</tr>
<tr>
<td>Remove waste from outside shed</td>
<td></td>
</tr>
</tbody>
</table>
## Work sheet 10. Flower quality check-list

Reject flowers that show the following:

<table>
<thead>
<tr>
<th>Quality problem</th>
<th>Present?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heads the wrong shape – not evenly shaped</td>
<td></td>
</tr>
<tr>
<td>Flower maturity not right</td>
<td></td>
</tr>
<tr>
<td>Flower maturity not even</td>
<td></td>
</tr>
<tr>
<td>Flower size not right</td>
<td></td>
</tr>
<tr>
<td>Large angle between stem and flower head</td>
<td></td>
</tr>
<tr>
<td>Damaged heads</td>
<td></td>
</tr>
<tr>
<td>Damaged leaves</td>
<td></td>
</tr>
<tr>
<td>Leaf blackening</td>
<td></td>
</tr>
<tr>
<td>Bent stems</td>
<td></td>
</tr>
<tr>
<td>Stem length – too short</td>
<td></td>
</tr>
<tr>
<td>Stem length – too long</td>
<td></td>
</tr>
<tr>
<td>Stem thickness – too thin</td>
<td></td>
</tr>
<tr>
<td>Stem thickness – too thick</td>
<td></td>
</tr>
<tr>
<td>Color not typical of variety</td>
<td></td>
</tr>
<tr>
<td>Insects present</td>
<td></td>
</tr>
<tr>
<td>Scale insects present</td>
<td></td>
</tr>
<tr>
<td>Fungi present</td>
<td></td>
</tr>
<tr>
<td>Flower drop</td>
<td></td>
</tr>
<tr>
<td>Flowers wilted</td>
<td></td>
</tr>
<tr>
<td>Soft tip growth</td>
<td></td>
</tr>
<tr>
<td>Side shoots/by-pass shoots</td>
<td></td>
</tr>
</tbody>
</table>

Comments ................................................................ Signature:..................................................................
7. Sources of further information

7.1 References

AFPGA 1998, Production workshop video, SA Branch, Australian Flora and Protea Growers Association, TCTV Productions, Kersbrook, South Australia, Phone (08) 8389 3057.

AFPGA 1998, Export workshop video, TCTV Productions, Kersbrook, South Australia, Phone (08) 8389 3057.


Beal, P., Howell, J., Joyce, D. and Shorter, T. 1995, Maturity Stages for Harvesting Grevillea for Cut Flowers, Department of Primary Industries Queensland and CSIRO. (From GrowSearch, Phone (07) 3821 3784).

Beal, P.R., Joyce, D.C. and Shorter, T. 1996, Tropical grevilleas vase life better than expected, Australian Horticulture, Vol. 94, No. 9, pages 43-47.

Beal, P., Howell, J., Joyce, D. and Young, K. 1998, Waxflower: Harvest Stages, Department of Primary Industries, Queensland, the University of Queensland and the Queensland Wax and Native Flower Association. (From GrowSearch, Phone (07) 3821 3784 or QW&NFA Phone (07) 4368 0966).


Dahlenburg, A., Tugwell, B. and Hill, J. 2001, Coolroom construction for the vegetable grower, South Australian R&D Institute (SARDI) and PIRSA, South Australia. From the Internet: www.sardi.sa.gov.au/ and go to Horticulture then Cool Chain (and find the entry point), or from Matthew Palmer, The Cool Handling Team, GPO BOX 397, Adelaide SA 5001, Phone: (08) 8303 9411, Fax: (08) 8303 9424.


Dubois, P. and Joyce, D. 1989a, Drying cut flowers and foliage, Farmnote No. 10/89, Western Australian Department of Agriculture.


Horticultural Research and Development Corporation (undated), The Competitive Edge: How to Make Quality Systems Work for You, Horticultural Research and Development Corporation (now Horticulture Australia Ltd), Sydney.

Hill, J. 2001, Thermometer Calibration at 0°C, Primary Industries and Resources, South Australia, from the Internet: www.sardi.sa.gov.au/ and go to Horticulture then Cool Chain (and find the entry point), or from Matthew Palmer, The Cool Handling Team, GPO BOX 397, Adelaide SA 5001, Phone: (08) 8303 9411, Fax: (08) 8303 9424.


IMS Publishing (undated), Agricultural and Veterinary Product Index – A Complete Chemical Product Guide, IMS Publishing, PO Box 977 Crows Nest NSW 2065, Phone (02) 9438 3588, Fax (02) 9906 3955.

Infopest, CD ROM, Queensland Department of Primary Industries. (From Infopest, Animal and Plant Health Services, DPI GPO Box 46, Brisbane Qld 4001, Phone (07) 3239 3936).


Palmer, M. 2001, Forced Air Cooling, Cool chain Information Kit No. 11, South Australian Research & Development Institute, from the Internet site: [www.sardi.sa.gov.au/](http://www.sardi.sa.gov.au/) and go to Horticulture then Cool Chain (and find the entry point), or from Matthew Palmer, The Cool Handling Team, GPO BOX 397, Adelaide SA 5001, Phone: (08) 8303 9411, Fax: (08) 8303 9424.


Seaton, K. 1988, Post-harvest insect disinfestation treatments for cut flowers and foliage, Farmnote No. 89/88 (Agdex 280/56), Agriculture Western Australia.


### 7.2 General reading

Carson, C. 2000, Should I grow wildflowers?, Agrilink Series, Queensland Department of Primary Industries.


Flower Register Australia, Rural Press, Phone (03) 9287 0900 or 1800 061 022.


Hortguide (reference magazine) Rural Press, Phone (03) 9287 0900 or 1800 061 022.


## 7.3 Useful organisations/contacts

<table>
<thead>
<tr>
<th>Growers’ Associations</th>
<th>State Governments</th>
</tr>
</thead>
</table>
| **Australian Flora and Protea Growers Association, AFPGA**  
Alison George, National Secretary  
Gaelforce Protea  
20 Trethowan Ave Marcus Hill Vic 3222  
Phone: (03) 5256 1494  
---  
**Flowers West**  
Executive Officer  
Phone: 0409 293 968  
E-mail: flowerwa@wentree.com.au  
---  
**Flowers Victoria**  
Mr John Osmelak,  
Chief Executive Officer  
Phone (03) 9210 9460  
---  
**Queensland Wax and Native Flower Association**  
Secretary  
Phone: (07) 4638 0966  
Fax: (07) 5638 5104  
---  
**Australian Native Flower Growers & Promoters NSW**  
Craig Scott, President  
Phone/fax: (02) 4374 1018  
---  
**Flower Growers Group of NSW**  
Sal Russo, Secretary  
Phone: (02) 9653 2380  
Fax: (02) 9653 2569  
---  
**Queensland Flower Growers Assoc Inc.**  
Mrs Geraldine Meiburg  
Executive Officer  
Phone: (07) 3824 9537  
Fax: (07) 3286 3094  
---  
**Flower Industry Association - Tasmania**  
Mr Colin Fleming  
Phone: (03) 6398 2474  
Fax: (03) 6398 2474  
---  
**NSW Agriculture and Fisheries**  
Ms Bettina Gollnow  
Phone (02) 4640 6333  
Fax (02) 4640 6300  
---  
**Primary Industries and Resources, South Australia**  
Lenswood Research Centre  
Phone (08) 8389 8800  
---  
**Cool Handling Team, South Australian R&D Institute (SARDI)**  
Matthew Palmer  
GPO Box 397, Adelaide SA 5001  
Phone: (08) 8303 9411  
Fax: (08) 8303 9424  
Internet site: [www.sardi.sa.gov.au/](http://www.sardi.sa.gov.au/) and go to Horticulture then Cool Chain (and find the entry point).  
---  
**Queensland Department of Primary Industries**  
Ms Cynthia Carson  
Redlands Research Station  
Phone: (07) 3286 1488  
Fax: (07) 3286 3064  
GrowSearch Information Service  
Phone/Fax: (07) 3821 3784
<table>
<thead>
<tr>
<th>Agriculture Western Australia</th>
<th>Department of Primary Industries and Fisheries, Tasmania</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gerry Parlevliet</td>
<td>Ms Nani Clark</td>
</tr>
<tr>
<td>Phone (08) 9368 3219</td>
<td>Phone: (03) 6421 7662</td>
</tr>
<tr>
<td>Fax (08) 9367 2625</td>
<td>Fax: (03) 6424 5142</td>
</tr>
</tbody>
</table>
| E-mail: GParlevliet@agric.wa.gov.au | Internet: [www.agric.wa.gov.au/programs/hort/floriculture/](http://www.agric.wa.gov.au/programs/hort/floriculture/) |}

<table>
<thead>
<tr>
<th>Agriculture Victoria</th>
<th>Institute for Horticultural Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department of Natural Resources and Environment</td>
<td>Agriculture Victoria</td>
</tr>
<tr>
<td>NRE Customer Service Centre</td>
<td>Department of Natural Resources and Environment</td>
</tr>
<tr>
<td>Phone: 136 186</td>
<td>Mr Tony Slater or Dr John Faragher</td>
</tr>
<tr>
<td>E-mail: <a href="mailto:customer.service@nre.vic.gov.au">customer.service@nre.vic.gov.au</a></td>
<td>Phone: (03) 92210 9222</td>
</tr>
<tr>
<td>Internet: <a href="http://www.nre.vic.gov.au">www.nre.vic.gov.au</a> then go to Farming - Horticulture - Wildflowers.</td>
<td>Fax: (03) 9800 3521</td>
</tr>
<tr>
<td></td>
<td>Internet: <a href="http://www.dpfif.tas.gov.au">www.dpfif.tas.gov.au</a></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Department of Primary Industries and Fisheries, Northern Territory</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr Mark Hoult</td>
<td></td>
</tr>
<tr>
<td>Phone (08) 8999 2338</td>
<td></td>
</tr>
<tr>
<td>Fax (08) 8989 2049</td>
<td></td>
</tr>
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<table>
<thead>
<tr>
<th>Australian Government</th>
<th>National Registration Authority for Agricultural and Veterinary Chemicals (NRA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment Australia</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The Manager, Wildlife Permits and Enforcement</td>
</tr>
<tr>
<td></td>
<td>GPO Box 636 Canberra ACT 2601, Phone: (02) 6274 2752 or (02) 62500 300</td>
</tr>
<tr>
<td>Rural Industries Research and Development Corporation (RIRDC)</td>
<td></td>
</tr>
<tr>
<td>Level 1, AMA House, 42 Macquarie Street Barton ACT 2600</td>
<td></td>
</tr>
<tr>
<td>PO Box 4776, Kingston ACT 2604</td>
<td></td>
</tr>
<tr>
<td>Phone: (02) 6272 4539</td>
<td></td>
</tr>
<tr>
<td>Fax: (02) 6272 5877</td>
<td></td>
</tr>
<tr>
<td>E-mail: <a href="mailto:rirdc@rirdc.gov.au">rirdc@rirdc.gov.au</a></td>
<td></td>
</tr>
<tr>
<td>Internet: <a href="http://www.rirdc.gov.au">www.rirdc.gov.au</a></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Australian Quarantine Inspection Service (AQIS)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Phone: Freecall 1800 020 504</td>
<td>Regional Offices are in state capitals.</td>
</tr>
<tr>
<td>Internet: <a href="http://www.affa.gov.au">www.affa.gov.au</a></td>
<td></td>
</tr>
</tbody>
</table>
### Other Organisations

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Internet site</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVCARE Ltd</td>
<td>National Association for Crop Protection &amp; Animal Health</td>
</tr>
<tr>
<td>Flower Export Council of Australia, FECA</td>
<td>PO Box 442, North Melbourne, Vic 3051</td>
</tr>
<tr>
<td>Innovating Horticulture Australia</td>
<td>Doug Hall</td>
</tr>
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</table>

### 7.4 Useful and interesting Internet sites

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Internet site</th>
</tr>
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<tbody>
<tr>
<td>Australian Flora and Protea Growers Association (AFPGA)</td>
<td><a href="http://www.afpga.com.au">www.afpga.com.au</a></td>
</tr>
<tr>
<td>Australian Quarantine Inspection Service (AQIS)</td>
<td><a href="http://www.affa.gov.au">www.affa.gov.au</a></td>
</tr>
<tr>
<td>Chrysal</td>
<td><a href="http://www.pokonchrysalusa.com">www.pokonchrysalusa.com</a> <a href="http://www.chrysal.co.uk">www.chrysal.co.uk</a></td>
</tr>
<tr>
<td>Cool Handling, South Australian Research and Development Institute</td>
<td><a href="http://www.sardi.sa.gov.au">www.sardi.sa.gov.au</a> then go to Horticulture and Cool Chain and find the entry point.</td>
</tr>
<tr>
<td>EthylBloc/1-MCP</td>
<td><a href="http://www.ethylbloc.com/">www.ethylbloc.com/</a></td>
</tr>
<tr>
<td>Flower Export Council of Australia</td>
<td><a href="http://www.feca.org.au">www.feca.org.au</a></td>
</tr>
<tr>
<td>Society of American Florists</td>
<td><a href="http://www.aboutflowers.com">www.aboutflowers.com</a></td>
</tr>
</tbody>
</table>
8. Explanation of terms

**Abscission:** Separation of one plant part from another, e.g. when a leaf, petal, or flower drop off the stem.

**Anhydrous:** Without water. Some chemicals have water bound to them and others are without water e.g. anhydrous sodium thiosulphate.

**Bract:** A leaf-like structure, usually below a flower head, sometimes brightly colored, e.g. in *Protea*, *Leucadendron* and *Telopea*.

**Calibrate:** To check the accuracy of an instrument against a standard. For example, a thermometer is calibrated by holding it in ice water, which is known to have a temperature of 0°C.

**Condense:** To form liquid from gas. Water droplets form on cold surfaces as the water vapor, or gas, in the air, cools as it comes in contact with the surface. For example, cold flowers or bottles taken from a cold room or refrigerator to room temperature, have droplets of water condense on them.

**Cultivar:** A cultivated variety. We use the term variety.

**Disinfestation:** To kill or remove pests (insects, spiders, mites etc.) from flowers. In this book, the term is used for postharvest treatments, applied as dips or gases (fumigants).

**Ethylene (chemical formula C₂H₄):** A natural gas produced by plants and by other processes, such as burning gases and fuels. It is a natural ripening, aging and defence hormone produced by fruit and flowers. It can cause individual flower and leaf drop and premature flower aging.

**Family (plant family):** A plant classification group of related genera (plural of genus). For example, the Proteaceae family includes the genera of *Grevillea*, *Protea* and *Telopea*.

**Flowers (the commercial flower):** For simplicity in this book, the words “flowers” or “stems” have been used to mean the whole commercial cut flowering stem, including the stem, leaves, flowers or flower head (made up of individual flowers or florets). For example the commercial flower of *Telopea speciosissima*, the waratah, includes stem, leaves and a flower head of individual flowers.

**Flowers (the botanical flower):** The word “flower” has also been used in this book to mean the individual flowers on a stem or in a flower head, e.g. the individual flowers of *Chamelaucium* and the individual flowers of *Telopea* within the flower head. Where it might be unclear whether we mean the whole, commercial flowering stem or the individual flower, the term “individual flower” has been used.
**Flower head:** The term “flower head” is used to describe the many compound flowers such as *Acacia* (balls or rods), *Banksia*, *Grevillea*, *Helichrysum*, *Ozothamnus*, *Protea* and *Telopea*. Botanically, this flower head is often called the inflorescence.

**Foliage:** A general term for stems with leaves but without flowers.

**Forced-air cooling:** Cold air is forced past flowers at faster than normal rates to achieve fast cooling. A fan pulls cold air through cartons, which are arranged in ways that encourage air movement through the cartons.

**Fumigant:** A gas used to treat flowers with, e.g. an insecticide gas such as methyl bromide, or 1-MCP the blocker of ethylene action.

**Genus (plural genera):** A plant classification group, of closely related species, the genus *Anigozanthos* has several species including *Anigozanthos rufus* and *Anigozanthos viridis*.

**Germicide:** A substance that kills germs, such as bacteria, algae, yeasts and fungi. Germicides can also damage other life forms, including people.

**Hybrid:** A new plant resulting from cross fertilisation of parents. These are then propagated vegetatively to keep the desirable characteristics of the hybrids.

**Hydrating solution:** A solution used to hydrate flowers, that is to increase water uptake and water content of the flowers. Citric acid, aluminium sulphate, wetting agents and some commercial solutions are used as hydrating solutions.

**Lux:** A unit of light intensity (or illuminance).

**Material Safety Data Sheet:** A sheet of information that is supplied with agricultural and laboratory chemicals when they are sold. It provides information on the safety of the chemical and how to use it safely.

**Mole (mol), hence millimole, micromole:** A chemical measure of the amount of a substance. A mole is an exact but huge number of atoms, ions or molecules (close to 600,000,000,000,000,000,000). A millimole (mmol) is 1,000th of that and a micromole (μmol) a millionth.

**Molar (M):** A chemical measure of the concentration of a substance in a solution. A molar solution contains 1 mole of a substance in a litre. A millimolar (mM) solution has 1/1,000 of a mole of the substance in a litre. A 4 mM solution of STS has 4/1,000 of a mole of silver per litre (equivalent to about 0.7g).

**pH:** A measure of the acidity or alkalinity of solutions. Pure water has a pH of 7, acid is below 7 and alkaline above 7.

**Passive cooling:** Regular cooling of flowers where they are placed in a cold room and allowed to cool. It is passive by comparison with forced-air or pressure cooling where the air is forced over or through the flowers. When the word cooling is used in this book it means passive cooling.
**Photosynthesis:** The conversion of light energy to chemical energy by plants. It is accompanied by the conversion of carbon dioxide and water to sugar and oxygen.

**Phytosanitary certificate:** A certificate to say that flowers have been inspected and are free from pests and disease. In Australia AQIS inspectors issue this.

**Precipitate:** To separate solid material from a liquid solution (e.g. silver from STS). The precipitate (noun) is the solid material that has separated from the solution.

**Proteaceae:** The plant family that includes *Protea, Banksia, Grevillea, Leucospermum, Leucadendron, Telopea* and many other flowers native to Australia and Africa.

**Pulsing:** A short term treatment of postharvest solution taken up by the flower stems.

**Relative humidity (RH):** The amount of water vapor in a quantity of air compared with the maximum amount of water vapor it would hold if it were saturated. It is expressed as %.

**Rutaceae:** The plant family that includes *Boronia, Crowea, Eriostemon* and citrus.

**Sepal:** A leaf- or petal-like part of the flower, just outside the petals, e.g. in *Ceratopetalum* the NSW Christmas Bush, the red sepals are just below the small white flowers.

**Species:** A plant classification group of closely related plants, all having a common set of characters that sets them apart from other species, e.g. *Anigozanthos rufus* is different from *A. viridis*. Sometimes sub-species are recognised.

**Stamen:** the male part of the flower that produces pollen. It consists of a thin, hair-like filament and an anther containing pollen. Stamens are very noticeable in *Acacia, Callistemon* and *Eucalyptus*.

**Style:** Female part of the flower that often sticks up in the centre of the flower. It receives pollen and transmits it down to the ovary. The styles are very noticeable in flowers such as *Banksia, Grevillea, Leucospermum* (the styles give it the pin-cushion name), *Telopea*.

**Turbid – turbidity:** Discolored, not clear or transparent.

**Variety:** Strictly speaking, this is a plant classification group, of similar plants, that differ from other varieties or groups of plants within the same species. For example, there are many varieties of *Leptospermum rotundifolium* including Lavender Queen and Jervis Bay. In this book the word is used for a cultivated, horticultural variety (sometimes called cultivar).

**Vase life:** The life of the flowers once they are placed in a vase. It is usually measured at 20°C, 60% to 70% relative humidity (RH) with lights on for 12 hours each day. The end of vase life is decided by the observer using some objective measure of quality e.g. when 50% of individual flowers have dropped, closed, or turned blue; or when 50% of leaves have more than 50% of their surface turned black. The vase life will be longer at lower temperatures than at 20°C.
Water stress: Water loss from the plant or flower that is greater than water uptake, so the plant becomes stressed or damaged.

Water Vapour: Water in the gas form e.g. in air. The more water vapour that is in air, the higher the humidity.

Wetting agent: A chemical that allows water to spread and move easily. A wetting agent in a postharvest solution can increase water uptake.