A 1988 Australian survey showed that the presence of insects in consignments of cut flowers is a major problem affecting the export cut flower trade. This is particularly the case for countries, such as Japan and the United States of America, which have extremely strict quarantine regulations. A postharvest treatment for insect control is therefore a necessary part of the handling process of cut flowers for export.

At present, the majority of exporters are not satisfied with the disinfestation treatments that are now in use. These conventional treatments do not always kill insects without damaging flowers. Consequently, improved and innovative methods are being investigated.

**Conventional postharvest treatments**

Optimum disinfestation treatments should, ideally, kill all insects in and on cut flowers and foliage, without causing damage to the produce. Conventional treatments in the export cut flower industry include:

- spraying with aerosols (for example, Pestigas® and Insectigas®)
- fumigation with methyl bromide
- dipping in insecticide
- use of slow-release insecticides (pest strips)

Application rates for common chemical treatments are given in Table 1. The suitability of each treatment depends on its effectiveness in killing the particular insects infesting the flowers, its phytotoxicity, its relative safety, and how well that treatment fits within the postharvest handling system.

Postharvest insect disinfestation can be necessary even where a rigorous pre-harvest insecticide spray program has been practised. This is because of the difficulty of killing certain insect species and because insects can be well protected within flowers.

**Aerosols**

Aerosols are not as effective as fumigants in penetrating flowers. Their effectiveness depends on the location of insects in flowers, the complexity of flower structure and the arrangement of flower bunches during spraying. Stand flowers loosely in buckets to facilitate better penetration of the insecticide.

For greatest safety, apply aerosols using a system like the ‘Space Controller System’ (Commonwealth Industrial Gases Ltd [C.I.G.]) which automatically controls dose, timing and venting.

No phytotoxic effects of aerosols have been found in experiments with waxflower (*Chamelaucium* spp.) and kangaroo paw.

**Fumigant**

Methyl bromide, being a true fumigant, exists as a gas and effectively kills insects that may be within plant tissue. It can be used on flowers already packed in cartons.

To meet quarantine requirements, flowers are usually fumigated at a rate of 32 g/m³ methyl bromide for two hours at 20 °C. Kangaroo paws were not damaged at this rate, but with waxflower, some flowers dropped. Fumigation of flowers at 32 g/m³ for two hours does not guarantee that they will pass quarantine inspection.
Fumigation for two hours at 48 g/m³ (at 20 °C) may help ensure the kill of insects. However, at 48 g/m³ methyl bromide for two hours (at 20 °C), kangaroo paws were blackened and waxflower dropped flowers. Methyl bromide has high mammalian toxicity, therefore its use is governed by regulations. Potential operators must obtain a licence from the Department of Health after completing a training course (cost approximately $500). Exporters must register their chamber and equipment. Alternatively, exporters can have flowers fumigated by registered contractors.

**Insecticide dips**

The effectiveness of insecticide dips depends on the species of insect pest and its stage of development (for example, larval or adult) and on the completeness of flower wetting during dipping. Flowers must be dried after dipping to avoid fungal problems.

Use of 250 mL Cislin® (10 g/L deltamethrin) per 100 L in dip plus wetting agent appears to be effective against the main insects found on waxflower, provided there is an adequate field spray program to control insect numbers. Dipping in insecticides is labour intensive and can pose a potential health risk to the operator. Protective clothing and equipment (for example, a respirator) must be worn at all times.

Some flower species may react adversely to particular insecticides which may potentially reduce vase life. Test for phytotoxicity before using any chemicals for commercial cut flower consignments.

**Slow release**

Pest strips have been used to discourage insects from entering cartons of flowers during transit. In trial air shipments, this method was only partially successful in killing test insects placed with flowers in cartons.

**Manual**

Manual removal of insects involves shaking bunches of flowers or striking them against a bench to dislodge insects. There is a risk of damage to flowers and the method is time consuming. However, manual techniques may be worthwhile for valuable flowers.

### Innovative treatments

New techniques for insect disinfestation should improve on conventional techniques by achieving one or more of the following:

- greater kill of insects
- less damage to flowers
- quicker disinfestation
- improved safety
- reduced cost.

Innovative insect disinfestation techniques under consideration in various parts of the world are listed in Table 2. Some of these techniques, such as hot water dips, are successfully used to disinfest fruit, low temperatures can be used to disinfest citrus during export in refrigerated sea containers. Combinations of treatments, such as low temperature following fumigation with methyl bromide at lower than usual (that is, non-phytotoxic) concentrations, have potential as improved disinfestation measures for cut flowers.

### Aerosol sprays

New aerosol insecticide formulations may prove more effective for disinfestation than those in wide use (pyrethrin and dichlorvos). Promising results have been obtained in Victoria with permethrin. However, in local research it was found that permethrin (applied from aerosol cans) was not as effective as pyrethrin (Pestigas®). Aerosol droplet size may influence effectiveness, and may explain why differences were found between two chemically similar formulations. (It may not be possible to reduce droplet size sufficiently to enable good penetration, so vapourisation is being investigated as an alternative method of applying permethrin.)

### Table 1 Conventional postharvest treatments used to disinfest cut flowers and foliage

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Insecticide</th>
<th>Rates and conditions during application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerosols</td>
<td>pyrethrin (Pestigas® P)</td>
<td>a.i. 2.6 to 5.6 mg/m³ (2 hours at 20 °C)</td>
</tr>
<tr>
<td></td>
<td>dichlorvos (Insecigas® D)</td>
<td>a.i. 32 to 64 mg/m³ (2 hours at 20 °C)</td>
</tr>
<tr>
<td>Fumigant</td>
<td>methyl bromide</td>
<td>a.i. 32 g/m³ (2 hours at 20 °C)</td>
</tr>
<tr>
<td>Insecticide dips</td>
<td>deltamethrin (Cislin®)</td>
<td>2.5 g deltamethrin (a.i. 10 g/L) per 100 L in dip plus wetting agent (agitated for 1 minute, plant material left to dry)</td>
</tr>
<tr>
<td>Slow release</td>
<td>dichlorvos-impregnated</td>
<td>One-fifth of a Shelltox® Household Pest Strip or one Shelltox® Ministrip per carton (approximate volume 0.07 m³)</td>
</tr>
</tbody>
</table>
Irradiation

Current quarantine regulations in Japan and the United States prohibit consignments of cut flowers containing any live insects. To kill hardy insects with gamma irradiation, a dose of about 10 kilogray (kGy) is required. However, a 10 kGy dose unacceptably damaged the species tested so far—waxflower, kangaroo paw and banksia. Therefore gamma irradiation is not recommended for disinfesting cut flowers.

(If quarantine regulations were changed so that insects were required only to be sterilised, then gamma irradiation may be feasible for some cut flowers and foliage, since much lower doses would be required.)

To set up an irradiation facility costs several million dollars.

Low temperature

This is an effective method of killing insects but requires up to two weeks at 0 to 1 °C. It may be an excellent method for use with sea transport. (It takes around three weeks sailing time for containers to reach Japan.)

Flowers can deteriorate during storage. Two weeks’ storage at 1 °C reduced the vase life of waxflower by 47 per cent. However, there was no such loss of vase life in banksias.

Flower deterioration during low temperature storage can be minimised. Dip flowers in a fungicide such as iprodione (Rovral®) for 30 seconds, allow to dry, then wrap in polyethylene (with perforations for air exchange) and place in a cold room (0 to 1 °C). To reduce flower drop in ethylene sensitive species, such as waxflower, pulse with STS (silver thiosulphate) or dip in NAA (naphthalene acetic acid) before storage.

Heat

Hot water dips can effectively control insects. However, experiments showed that banksia quality deteriorated following a 20 minute dip in water at 46 °C or a 10 minute dip in water at 56 °C. The hot water caused many florets to open and pollen was washed from the flowers.

Vase life of waxflower was reduced by 26 per cent after dipping for 20 minutes at 46 °C. It was reduced to zero with extensive damage (bluing of flowers and browning of foliage) after dipping for 10 minutes at 56 °C.

Microwave heating at 600 watts for 10 seconds caused extensive damage (browning of flowers and foliage) of waxflower and 81 per cent loss in vase life. It was not effective in controlling insects. Use of vapour heat has not yet been tested as a method for disinfesting flowers.

Combined treatments

A combination of two or more disinfestation treatments may enhance the kill of insects, improve safety (for example, by reducing the concentration necessary to kill insects) and cause less damage to flowers and foliage than any single treatment. As cold storage is a normal part of postharvest handling of cut flowers, combinations which involve cold storage are convenient.

Low temperature plus carbon dioxide

Low temperature alone may not be a satisfactory method of disinfestation for flowers, because it takes at least two weeks and uses up cold room space. The time required to kill insects may be reduced by using high carbon dioxide (CO₂) atmospheres in the cold room. The level of insect mortality depends on the CO₂ concentration, the
length of time at that concentration and the types of insects present.

Because elevated CO₂ also affects flowers, it is necessary to identify the CO₂ concentration and exposure time required to kill insects without damaging the flowers. Longer exposure to and higher levels of CO₂ are more likely to kill insects, but also to damage flowers. Short treatment periods are preferable for cut flower handling, but involves high levels of CO₂.

In controlled atmosphere experiments, flowers were placed with their stems in water (to increase their vase life) or a solution of 2 per cent w/w sugar plus 200 mg/L 8-hydroxyquinoline sulphate (8-HQS) in plastic storage chambers in a cold room. The flowers were then exposed to elevated CO₂ atmospheres by mixing CO₂ from a gas cylinder with compressed air and passing the mixture through the chambers. At a concentration of 45 per cent CO₂ at 0 to 1 °C, it took about one week to obtain effective control of test insects.

Fumigation followed by low temperature
Because exposure to low temperatures will kill insects, if fumigation is followed by refrigerated storage it may be possible to reduce the concentration of methyl bromide (fumigant) used. Lower concentrations of methyl bromide should cause less damage to flowers.

Conclusion
Some of the innovative disinfestation treatments described in this Farmnote show promise, especially those involving combinations of treatments. However, further experimentation is necessary to evaluate their full potential. With more effective disinfestation treatments, Australia’s share of the export market will expand.

Further reading
Seaton KA & Joyce DC, 1988, Quarantine disinfestation. A bibliography with relevance to ornamental plant material, W Aust Dept Agric, Misc Publ No. 13/88 9pp.

Seaton KA & Joyce DC, Australian cut flower and foliage export—a survey with emphasis on postharvest insect disinfestation (submitted to Aust J Exp Agric).

Note: Mention of trade names does not imply endorsement or preference of any company’s product by the Department of Agriculture and Food, Western Australia, and any omission of a trade name is unintentional.