Integrated pest management in ornamentals information kit

Reprint – information current in 2000

REPRINT INFORMATION – PLEASE READ!

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This publication has been reprinted as a digital book without any changes to the content published in 2000. We advise readers to take particular note of the areas most likely to be out-of-date and so requiring further research:

- Chemical recommendations—check with an agronomist or Infopest www.infopest.qld.gov.au
- Financial information—costs and returns listed in this publication are out of date. Please contact an adviser or industry body to assist with identifying more current figures.
- Varieties—new varieties are likely to be available and some older varieties may no longer be recommended. Check with an agronomist, call the Business Information Centre on 13 25 23, visit our website www.deedi.qld.gov.au or contact the industry body.
- Contacts—many of the contact details may have changed and there could be several new contacts available. The industry organisation may be able to assist you to find the information or services you require.
- Organisation names—most government agencies referred to in this publication have had name changes. Contact the Business Information Centre on 13 25 23 or the industry organisation to find out the current name and contact details for these agencies.
- Additional information—many other sources of information are now available for each crop. Contact an agronomist, Business Information Centre on 13 25 23 or the industry organisation for other suggested reading.

Even with these limitations we believe this information kit provides important and valuable information for intending and existing growers.

This publication was last revised in 2000. The information is not current and the accuracy of the information cannot be guaranteed by the State of Queensland.

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

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Queensland Government

Designing an **IPM Program** *monitoring & decision making*

What can you expect to learn from this section?

How to monitor your crop and what you need to do this. Monitoring for pests and diseases is one of the key aspects of an IPM program. Handy Guide 1, IPM Checklist *and* Handy Guide 3, Record Sheets, *will assist you put an effective monitoring program in place on your property.*

In this section we look at the importance of structured monitoring in steering a successful IPM program, and how this encourages effective decision making. Ideally, you should have adopted many of the recommendations in the previous section on preparing your property and staff for IPM. It will make this part of the program that much easier.

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What is monitoring?

Growers often claim that they inspect their crops and know what is affecting them, but do they really? You are not monitoring for pests and diseases if you are merely checking the occasional plant that looks sick while you are doing other tasks.

Monitoring involves:

- **one or more trained individuals**, who might include the grower, staff members, consultant or private scout
- **regular crop inspection (scouting)** for pests and diseases
- **using sticky traps** to trap small, winged insect pests (mostly useful in covered crops such as greenhouses)
- **recording data and retaining** it in a form that is easy to refer back to, and for analysing trends and events.

Why monitor?

Monitoring, along with accurate identification of pests and diseases in crops, is a cornerstone of every IPM program.

IPM consultant (left) discussing a pest problem with grower

Information obtained from a monitoring program can enable you to:

- **detect pests and diseases early**, before they become economically damaging
- **improve timing** of chemical and biocontrol treatments
- **collect information** on the effectiveness of the treatments applied
- **reduce pesticide use** by adopting targeted spot spraying
- **adopt a pro-active approach** rather than a reactive one
- **increase your knowledge** of plant–pest relationships
- **detect problems** with cultural management strategies.

For you to continue with a monitoring program, it must be:

- realistic
- affordable
- sustainable.

Wayne Bacchi, from Wholesale Indoor Foliage in Queensland, has been practising IPM for 10 years. He believes:

"It is very important to do an environmental audit (pests/beneficials) of the nursery and find out what's in the nursery and the surroundings. Overall, the monitoring frequency is driven by the pest/disease problem and the environmental conditions. If it is dry and hot we monitor every three to seven days; during winter we monitor fortnightly."

Use a headband magnifier to monitor for pests and diseases; keep records as you go

Who does the monitoring?

The preferred model is for trained staff in conjunction with a privately employed IPM consultant to monitor crops. At least two staff members should be trained to maintain continuity during absences through illness or holidays. It is also a good idea for other horticultural staff members to receive training. This training serves two purposes: it provides many more pairs of eyes that can identify and report early stages of pest problems or disease outbreaks, and it can provide greater job satisfaction for these staff. Their training may be restricted to learning to recognise pests and diseases or their symptoms. Management or specialist IPM staff should be responsible for further action.

Consultants or IPM specialists, who may also act as scouts, are available in most areas to work with growers. Their role can vary depending on the cost and the grower's needs. An IPM specialist can help you set up a program and be the scout for a time, and your trained staff should work with the consultant. You may gradually reduce your reliance on the consultant to a basic service to ensure that all is well, or to provide advice on a specific problem.

What level of service do you want?

An IPM service offered by a consultant is generally negotiable and may provide:

- weekly or fortnightly visits to provide a scouting service with problem diagnosis and recommended action, and to change and monitor sticky traps
- an agreed number of annual or seasonal monitoring visits to back-up on-site, trained staff with problem diagnosis and recommended action
- advice on an as-needed basis.

Staff are usually responsible for ordering biocontrol agents and pesticides, and their application, but may be guided by the consultant's advice.

Basic equipment checklist

You will need some basic equipment for monitoring. Many of these items are an initial outlay only and not an ongoing expense.

- **Head band magnifier.** Provides 3.5x magnification and good scanning capabilities, while leaving the hands free to inspect plants and record observations and data. Powerful enough to recognise spider mites, and perhaps broad and cyclamen mites, depending on your eyesight, but inadequate for eriophyid mites.
- **Hand lens.** Provides 10x or 20x magnification. Useful for closer identification.
- **Sticky traps.** Yellow for general pest monitoring, blue for western flower thrips.
- **Set of diagnostic cards,** *Pests, Diseases, Disorders and Beneficials in Ornamentals: Field Identification Guide*, see *Section 10, Further reading.*

- **Recording sheets and clip board**. Tie a piece of string to the board so that it can hang around your neck, leaving your hands free.
- **Apron with pockets** for holding monitoring tools and diagnostic cards.
- **Flagging tape** for marking infestations on plants, or placing tape at the end of the row in greenhouses to alert scouts to infested plants within a row. Different colours can be used for different pests.

If there are weeds around, these should be monitored as well before removing them

- **Permanent ink pen** for dating and numbering sticky traps and **pencil** for recording data on sheets.
- **Plastic vials or bags.** Useful for taking samples for identification by microscopic examination or sending to a diagnostic facility, or rearing immatures out to adulthood.
- **A white plastic pail,** for example ice cream pail. Tap flowers or foliage over it to detect thrips and other hidden or very mobile pests.

Other useful items include hand cleaner (for example citrus or eucalyptus oil-based products) to remove sticky trap glue from hands and clothing, a microscope (especially for identifying western flower thrips) and a camera (invaluable for documenting damage symptoms by pests, diseases and chemicals).

What is the best way to monitor for pests and diseases in my crop?

In practical terms, you want to collect the least amount of data needed, without sacrificing accuracy, to decide whether or not a treatment is required. In short, adopt a routine that meets the needs of both your crop and time.

The frequency of monitoring will depend on your crop production cycle and the time of the year. In cooler months you can extend the gap between monitoring, while in warmer seasons you should monitor weekly. If you live in areas with continual warm temperatures, you may find that weekly monitoring is necessary all year round.

Wherever you are, use your experience to develop a program that best suits you and your operation. Start conservatively and adapt as experience dictates. Don't take unnecessary risks by taking short cuts at the beginning.

You will have noticed by now that there is a bit of '*might*' and '*maybe*' about this advice. There is no single prescriptive approach to monitoring. Your monitoring program will be based on the following:

- **Size of property.** You can't spend all day monitoring. Systems have to be devised to accommodate large and small properties.
- **Range of plant types.** Bedding plant producers have many small units whereas growers of advanced containers have fewer units. With advanced containers don't attempt to examine the whole plant; look at sample areas. With small plants you can quickly examine the whole plant. Certain species attract specific pests and diseases and can be used as indicator plants to speed up scouting.

- **Degree of susceptibility of different plant types.** Some plant types or cultivars are particularly prone to infection or infestation. They make good indicator plants, but you might ask if they are really worthwhile growing. Is there a similar cultivar that is less susceptible?
- **Frequency of pest and disease incidence.** Some pests can occur at any time of the year, while others are seasonal. Regular monitoring and good record keeping over several seasons will enable you to predict future occurrences. See *Section 8, Crop notes, recording pest and disease information*, page 2.
- **Climatic constraints** on pests and diseases influence frequency and seriousness of outbreaks. Hot weather, strong winds and cool moist weather can all influence pest and disease severity, and the effectiveness of natural enemies.

Ian Collins from Colourwise Nursery in NSW, who has been practising IPM for six years, says:

"We identify pests and diseases using a combination of staff experience and external diagnostic services such as the NSW Department of Agriculture. A consultant provides a trap monitoring service for us, and we monitor every two weeks using a trained employee as a scout. We also use an external scout."

What is the best way to inspect crops?

There are two aims to a crop inspection. One is to detect **symptoms** of pests and disease attack (for example yellow foliage, necrotic spots, leaf stippling, wilting, stickiness) by scanning the crop. The other is to **detect pests and diseases** *before* they produce obvious symptoms by randomly examining plants. Anyone who has scouted will know how difficult it is to do both at the same time without becoming distracted. The best solution is division of labour.

Use your general staff (with basic training) to look out for symptoms of ill health or presence of flying pests during routine handling of the crop. A system of flagging and/or recording problem spots will mean the scout's/consultant's time is better spent checking those areas more thoroughly during his/her regular visit. The scout can then revisit the crop to conduct random checks. Ideally, these random checks detect pests and diseases before they spread or cause any serious damage, but don't fire the scout if some infestations are not detected. It is impractical to check every plant, and some problem spots will be missed. Remember that your objective is to reduce pesticide use to spot applications, not necessarily to eliminate all use. On the other hand, the discovery of broad areas of crop with extensive pest populations or damage indicates that crop inspection has been inadequate.

Putting it all together
This section page 15

Use sticky traps as an additional monitoring tool. They are in place when you aren't and can provide an early warning system.

Record what you find. It helps you to plan ahead and track the results of changes you have made.

Handy tips to assist you in developing your crop inspection program

- **Draw up a 'key plant–key pest/disease' list.** In a typical plant production business with a wide range of plants, you can't be expected to monitor every plant type permanently. The consultant and/or operation manager should agree on a 'key plant–key pest/disease' list as a starting point. However, when developing your scouting schedule, make sure you assess each plant type until you are familiar with the degree of risk to pests and diseases.

Keeping records
Crop notes
Section 8

Low risk plants can be given less intensive, less regular inspections than susceptible species or cultivars. Don't forget pests and diseases may only appear at certain times of the year or under favourable environmental conditions.

- **Use the information from the sticky trap catches.** Most whiteflies gravitate to traps in the immediate area of an infested plant and these represent the bulk of the catch. A few individuals in every population are travellers; these may end up some distance from where they originated and indicate where future infestations may occur. A trap with a high whitefly count relative to others indicates you should be searching for a localised infestation. A trap with high thrips numbers may indicate a very local infestation, but the catch can be influenced by wind currents and competing flower crops. Check nearby flowers, but generally use thrips-catch information as an indication of general greenhouse population levels or blow-ins. Aphids are only found on traps when populations on plants are crowded, or they are blown in from outside. Their presence in a screened house indicates there is a serious infestation nearby (it may be on only one or two plants).

Lupin baiting
Section 6 page 17

- **For soil-borne disease detection,** consider using the lupin baiting method for each batch of growing media.
- **Train general staff to recognise symptoms**. This will save time, should reduce costs and improve monitoring efficiency. Staff members work in the crop each day so they can 'flag' problem areas or plants with abnormal conditions for closer inspection by the trained scout. Symptoms might include plant malformation, yellowing and browning, wilting, disturbance of flying insects when plants are handled, holes and spots on leaves. Other reporting aids might be a map of the production area on a whiteboard, with colour-coded magnetic buttons to identify key pests and diseases and to indicate problem areas, or comments sheets in production bays.
- **Follow through on information and recommendations given to you by the scout**. A frustrated scout becomes a careless scout and loses enthusiasm for the job very quickly.

Hints for scouts

Scouting needs to be done on two levels: biased and random. In a small operation, it is a good idea to go through the crop twice. During the first inspection, you are concentrating on obvious symptoms of ill health or pest attack (the assistance of trained general staff will make this job much easier); the second time you are selecting plants without deliberately looking for sick or infested ones. During the second inspection, you are doing a random check. Once the trained scout is familiar with the crop and its peculiarities, the random check can also become biased towards more thorough and frequent checking of problem areas and susceptible plant species or cultivars. Use these techniques:

- **Conduct biased sampling.** You are looking for signs of abnormality or symptoms of pest and disease activity, such as yellowing, distortion, cast skins or stickiness. When you notice a problem, increase sampling around these areas to estimate the size of the problem.

- **Use coloured flagging tape and other reporting aids.** Mark any signs of pest and disease occurrence with coloured flagging tape loosely tied to the plant or a simple flag that can be stuck into a pot. For small numbers of infested plants, tie the flagging tape around them. This serves as a marker for spot spraying and subsequent control. Use a permanent pen to write the nature of the problem and observation date on the tape. Staff can learn from checking these tapes. Remember to remove the tape when it is no longer needed. Put up comments sheet for staff to add their observations; put up your own comments sheet to keep staff informed and interested.
- **Check unthrifty plants.** Check roots of wilted plants or those with yellowing foliage. Tap the plant out of the pot. Look at root colour, for example browning of feeder roots, and for signs of poor root growth; check for mealybugs, curl grub, root aphids and disease problems.
- **Check the crown, middle and lower areas of the plant.** Many pests, for example western flower thrips, broad mite and green peach aphid, occur in the new growth, where damage may not be obvious until it grows out. On the rest of the plant, most pests are found on the underside of the leaf.
- **Pay particular attention to buds and blooms.** Tap buds and blooms over a sheet of white paper or into a white container to dislodge thrips and other insects. Gently blow into blooms to increase insect activity, such as thrips, to make them more conspicuous.
- **Be aware of the most likely places to find pests and diseases.** Insect and mite infestations often build up at the ends and edges of benches. Diseases may develop near evaporative coolers where humidity is higher; powdery mildew and *Botrytis* may spread in the direction of airflow. In greenhouses, concentrate on vents and doorways for incidence of pests and diseases. Warmer, drier areas in greenhouses will favour two-spotted mite; don't ignore stock plants and hanging baskets.
- **Note presence and type of weeds** and schedule them for removal. Check weeds for pests. Look outside of the crop to see if plants in the surrounding area could be contributing to pest problems in the production area.
- **Don't forget plants in hard-to-get-at areas!** Check plants at the back of benches, in far corners, and in hanging baskets.
- **Write it all down!** Storing information in your head only uses up space and does no one else any good.

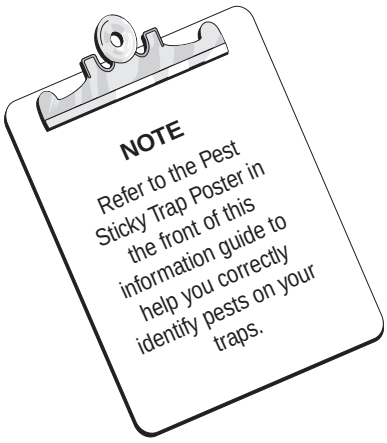
Some common symptoms to look for

Know your pests
Section 5

Colour photographs of pests and their damage symptoms, and some information on characteristics and biology, can be found in the companion guide *Pests, Diseases, Disorders and Beneficials in Ornamentals: Field Identification Guide,* see *Section 10, Further reading* page 7. Table 1 lists key pests, describes where they occur on the plant, and symptoms to look for.

***Table 1**. Some common symptoms of pests in ornamentals and where to look for them*

Pest	Location on plant	Symptoms to look for
Aphids	Some species congregate in growing tips and can be easily seen, while others are found on the underside of leaves or on stems. There are also species that live on roots.	May cause rolling of leaf edges, leaf twisting and distortion, reduced growth and yellow spots. Honeydew deposited on leaves below, produces a shiny appearance and allows growth of black sooty mould. Ants may be attracted to the honeydew. Cast white skins on upper leaf surfaces.
Black vine weevil, African black beetle	Grubs below soil surface, adult vine weevils on foliage at night.	Poor growth, wilting. Black vine weevil chews notches in flowers and foliage. Take plant out of pot, check for brown-headed, white, C-shaped grubs in vicinity of roots.
Broad and cyclamen mites	Growing tips for both, with some broad mite seen on the youngest opened leaves.	Tightening of the growing area, extension of internodes, bronzing of young foliage and malformed growing tips, later developing into malformed leaves.
Caterpillars	Anywhere on the plant depending on the species.	*Heliothis*—look out for eggs laid singly on bud calyxes. Will eat holes in buds and chew flowers. Loopers—eggs laid singly on under sides of leaves. Chew obvious holes in leaves. Produce large faecal pellets, which can be visible on lower leaves. Cluster caterpillar—eggs laid in hairy, buff-coloured masses. Large numbers of small caterpillars can badly skeletonise leaves. Lightbrown apple moth—lays pale green eggs in rafts on leaves. Caterpillars live in hides formed by leaves held together by silk threads.
Eriophyid mites, e.g. bud mites, rust mites	Growing tips and some leaf surfaces.	Bud distortion leading to malformed leaves and shoots, russeting of leaf surfaces.
False spider mites	Mostly on underside of leaves along veins.	Bleached appearance alongside the veins caused by mite feeding. Red eggs. No webbing.
Fungus gnats	Near surface of potting mix, especially those high in organic material; root tissue and inside lower stems and crowns.	Collapsed seedlings associated with small black flies and transparent, black-headed larvae. Damage roots, tunnel into stems at soil level, may tunnel into crowns. Often associated with wet media and root and crown rots. May spread soil-borne pathogens e.g. *Pythium, Phytophthora.*
Mealybugs	Mostly in axil of shoots and leaves and on stems, sometimes on roots.	New growth stunted and distorted, yellowing of foliage. Cottony material associated with eggs of most species. Honeydew deposited on leaves below, produces a shiny appearance and allows growth of black sooty mould. Ants may be attracted to the honeydew.
Scale insects	Varies with species. May be on leaves, stems or trunks.	Poor growth, yellowing foliage. Feeding by armoured scales produces yellow or brown flecks or thin tracks (toxin produced). Soft scales produce honeydew on leaves below, producing a shiny appearance and allowing growth of black sooty mould. Ants may be attracted to the honeydew.
Shore flies	Wet areas with algal growth e.g. pools of nutrient-rich water; media surface where there is algal growth.	Transfer soil-borne pathogens. Adult flies cause soiling of leaves due to faecal deposits.
Spider mites	Mostly on leaf undersides, sometimes upper surface. May infest flowers.	Stippling showing on upper surface of leaves caused by mite feeding on the underside. Yellowing and browning as damage increases, followed by defoliation. Webbing often present when severe.
Thrips	Lower surface of leaves and in terminal growth, buds and flowers.	White stippling or streaking on lower surface of leaves and on petals. Small dark faecal spots associated with damage. May cause malformation and stunting of new growth and flowers, causing deformed, streaked petals. Some species only on leaves, others favour flowers.
Whiteflies	Underside of leaves. Adults emerge from pupae on lower leaves, but most eggs are laid on underside of new growth.	At low population levels look out for white adults, easily disturbed from young growth. On heavily infested plants, honeydew is deposited on leaves below, producing a shiny appearance and allowing growth of black sooty mould. Ants may be attracted to the honeydew. Plants yellow and lack vigour.



Using sticky traps

Many growers have difficulty in identifying insects on sticky traps, but properly used, traps can be a valuable pest management tool. Watch an entomologist make a beeline towards your traps as the first port of call!

- **Why should I use sticky traps?** When used properly, traps can give you early warning of whether a pest is present or absent, indicate where an infestation is located, or tell you how well your management program is working.
- **What is a sticky trap?** A sticky trap is a flat, coloured (usually yellow or blue), rectangular surface covered on one or both sides with a thin layer of water-resistant sticky substance that neither runs nor dries out. The colour of the trap attracts flying insects to the sticky surface. Sticky traps commonly come in two basic sizes: a small trap around 10 x 15 to 25 cm, and a larger trap about 20 x 25 cm. Some trap types come with a grid pattern, which is handy for counting large populations of pests. Traps can also be long strips or films, but these are less common. Strips or film can be hung vertically or horizontally along the full length of a greenhouse row and up and down several rows in a greenhouse, or along the sidewalls.
- **Which size should I use?** The essential difference between the small trap and the larger trap or strip is that the small trap is used to monitor early signs and continuing changes in pest populations, whereas the larger trap and strips or film are used as a partial control measure.
- **What do sticky traps catch?** Sticky traps catch small, winged insect pests including whiteflies, thrips, aphids, fungus gnats, leafminers, green mirids and shore flies. They do not catch wingless pests such as mites, mealybugs, scale insects and caterpillars, or large flying pests such as moths, beetles, and some bugs. Yellow traps may also catch beneficial insects. They should be used sparingly if you are using aphid parasitoids or lacewings in an IPM program.

One way of setting up sticky traps in a crop

- **Which colour is best?** Commercial traps are either yellow or blue, though many more yellow traps are sold because of their all-purpose nature. Whiteflies, fungus gnats and aphids are more attracted to yellow sticky traps than to blue. However, blue traps generally catch more western flower thrips than yellow. Although western flower thrips is the most significant thrips pest, other species in the *Thrips* genus, such as onion thrips, gladiolus thrips and melon thrips, may be more attracted to yellow traps. Thrips are more difficult to see on blue traps than yellow, so the only real advantage of blue traps is narrowing the range of species, good and bad, that you have to sort through. White traps also attract thrips, and are sometimes used in State diagnostic or monitoring programs.
- **Can I make my own traps?** Apart from the messy business with the glue, which generally results in a rapid loss of enthusiasm, all yellows, blues or whites are not equal. The wavelength in the spectrum visible to an insect may vary considerably. For example, an ultraviolet-absorbing white is not attractive to thrips, even if it looks the same as a white that does not absorb ultraviolet. It is best to stick with commercial traps.

Sticky traps can be hung and locations numbered for easy reference

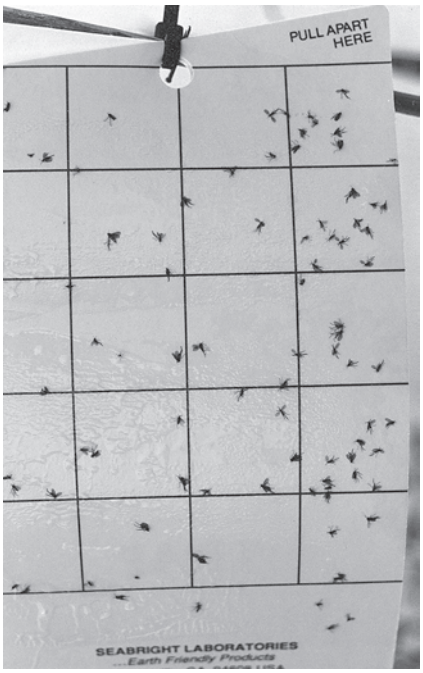
more info
Sticky trap suppliers
Section 9 page 6

The double clothes peg attachment system lets you alter the position of the sticky trap as the crop grows. Make sure you number the trap's position

- **What types of sticky trap are available?** Several brands of sticky traps are available in Australia; all are imported. The two most commonly available in the Eastern States are the SEABRIGHT™ trap made in the USA, and the AGRISENSE™ trap made in the UK. The SEABRIGHT™ trap has a grid surface that makes scanning and counting much easier, but the adhesive is messy. The AGRISENSE™ trap now comes with a pressure-sensitive adhesive similar to that used to seal envelopes. The advantage is that users no longer get sticky when they handle the trap. Both brands are available from chemical/produce outlets in most areas and by mail order from these and other outlets.
- **Where should I place traps?** In greenhouses, traps should be placed near doorways and vent areas and in blocks of susceptible plants. When susceptible plants are moved, take the traps with them to the new location. Keep traps away from sprinkler heads where they will get wet, and walkways where they can catch people. Sticky traps can be used outdoors to monitor pest movement and to detect the early arrival or large scale movement of pests. However, the adhesive will accumulate dust and other debris on windy days, making it harder to identify and count insects stuck to the surface. Many wind-blown and passing insects of no importance will also be trapped.
- **At what height should traps be placed?** For most pests, traps should be positioned just above crop height for maximum effectiveness and their height adjusted as the crop grows. For soil-dwelling pests (fungus gnats, shore flies) place traps near the ground, unless mud splashes are a problem.
- **How can I attach traps?** Traps can be placed in potted crops by fixing the trap to a bamboo stake with a peg and sticking the stake into the pot. A permanent, concrete-filled pot with a long stake is also handy, but less mobile. A double clothes peg arrangement where two pegs are stuck together back-to-back, one for attaching to the stake and the other for holding the trap, works well. In row crops, sticky traps can be hung on or attached to tomato stakes, trellising, or to variable length chains hung from horizontal supports.
- **How many traps should I use?** There are no hard and fast rules to the number of traps you need. If you are growing a crop that is highly attractive to flying pests such as whiteflies and thrips, start by setting up one trap per 200 sq m. This may result in more traps than you want or can manage. Remember that your monitoring program must be manageable. Over time, reduce the number of traps to those providing you with the most information. You may need to readjust this with each new crop. If you are growing a crop not susceptible to the key flying pests, you may not need any traps.
- **How should I use the information provided by the trap?** If traps are checked weekly or every two weeks, they can provide current information on several activities. This includes the presence or absence of a particular pest; whether the population is increasing or decreasing (either naturally or through a control action); where the pest population is concentrated; or whether an action threshold (chemical or biological control) has been reached. The interpretation may be different for different pests. Experience and good record keeping will tell you what your action threshold is for each crop and crop stage, and whether an

area treatment or spot treatment is necessary. Traps in fixed positions can be useful tools to track seasonal changes in pest incidence.

- **How do I interpret what I find?** For whiteflies there is a good relationship between numbers caught on sticky traps and percentage of plants infested. The relationship is almost on a par—five whiteflies per trap per week equals about 5% of plants infested with one or more whiteflies. A further interpretation is that this is too many to start a biocontrol program, and too many at the start of a crop, but many growers would be happy with this at point of sale. For thrips, the relationship is not as clear. In a thrips-susceptible crop, particularly if virus transmission is an issue, five thrips per trap per week may be an action threshold. In other crops, 50 thrips per trap per week may not be an issue.
- **What can affect the success of sticky traps?** Trap counts can be influenced by wind currents, insect blow-ins, and whether the crop is flowering or not. A trap hung over a chrysanthemum crop in flower may have a lower count than one over the same crop before flowering, not because there are fewer thrips, but because the flowers are more attractive than the trap.
- **How can I recognise the different bugs on my trap?** Although the sticky trap appears to be a simple monitoring tool, users must learn how to correctly identify pest species for their monitoring to be effective. This information is provided in a national training course in IPM, with additional assistance from aids such as the Pest Sticky Trap Poster. You may want to send the traps to a monitoring service that will identify pests for you, but it's good to learn to recognise the main pests yourself so that there is no delay in treatment. If you number the traps and have a simple mud map showing their location, you can easily relate the trap data to that location and follow changes over time.



Fungus gnats on a sticky trap

Example of a monitoring program using sticky traps

You have a 10,000 sq m nursery producing 20 plant lines, and you are just starting a monitoring program. You know from past experience that the Chamaedorea *gets two-spotted mite, soft scale and mealybug, that gerbera gets fungus gnat, whitefly, two-spotted mite, powdery mildew and* Botrytis, *and that African violets get cyclamen mite and western flower thrips. The rest you are unsure about.*

Fifty traps have been put out: two blue ones among the African violets to monitor western flower thrips, three yellow in the gerbera, and the rest randomly placed and ready to be moved or removed as necessary, depending on scouting information and whether they catch few or many pests. You are also acquiring literature on pests and diseases relevant to the lines that you are growing.

To start with, check comments sheet and talk to key staff about any problems they have noted. Monitor for two hours including the time taken to scan and change the 50 sticky traps. Walk through the crop looking for visible signs of damage. Pay special attention to the susceptible species or cultivars and scout the others as time permits. Randomly check about one plant every 2 to 4 m in pest and disease-prone plant types; search more thoroughly within a 5 m radius of

traps with high numbers of whiteflies, thrips or fungus gnats. Look especially for the pests known to occur on particular plants.

In the African violet, check the flowers for tell-tale pollen spills indicative of western flower thrips, and the new growth for signs of distortion caused by cyclamen or broad mite. In Gerbera, *blow in the flowers or tap over white paper to dislodge western flower thrips. Check the undersides of the leaves for spider mites and whiteflies, and the upper sides for powdery mildew. Check at the stem/soil interface for fungus gnat larvae, and look for crown rot caused by pathogens along with fungus gnat larvae or fruit flies. In the* Chamaedorea, *check lower leaf undersides for spider mites, look for white cottony fluff at internodes and on leaves indicative of mealybugs, and look for honeydew on upper leaf surfaces indicative of soft scales or mealybugs on leaves above. If using biocontrol agents, check that they are present in all infested areas, and whether you need to add more or apply a short residual or compatible pesticide.*

Set out to monitor weekly. After several occasions, review your monitoring procedure. Is two hours long enough? Too long? Are there too many traps? Make changes according to your needs. Remember that there are seasonal influences that may increase or decrease time spent monitoring.

- **How do I send traps away for checking?** If your traps tend to sit there unloved and not looked at once you put them out, there are consultants who will check them for you. Talk to the consultants first to see how they would like traps sent. The SEABRIGHT™ trap has glue on one side only and can be folded without making key pests unrecognisable. Other trap types can be covered with shrink-wrap plastic.

Pest and disease diagnostic services
Section 9 page 8

Kylie Stewart from Colour Options nursery in NSW, who has been practising IPM for two years, says:

"The sticky traps are monitored every fortnight, but during the week our packers would have a fairly good idea of what is going on in the crop, so they'd report back with that information. We check the plants ourselves, and we monitor throughout the crop's lifecycle. We also send our sticky traps to a consultant for pest identification."

Action thresholds and damage thresholds

An **action threshold** is the point at which a treatment must be applied to prevent pest numbers from reaching the damage threshold. The action threshold may be very early in pest or disease development if you are incorporating biocontrol agents or using a management approach with spot applications of pesticides, or later at higher pest densities or disease incidence if you are relying solely on curative pesticides.

A **damage threshold** is the point at which the pest or disease will cause economic damage unless it is controlled immediately. Your management plan is to avoid reaching this threshold.

Action thresholds are sometimes hard to determine, but there is a lot more flexibility in the response time and treatment options than for a damage threshold. The following questions may help you in making a decision.

What is the potential for damage?

- **It is important to identify the pest/disease species**. For example, in a chrysanthemum crop, leafhoppers can be present in high numbers and cause minimal damage, whereas a few green mirids can tip-kill many plants before they are noticed. *Thrips nigropilosus* looks very similar to western flower thrips but feeds only on lower leaves and generally causes

only minor damage. Only western flower thrips damages the new growth. Make sure you know the damage potential of all pests and associate the right pest with damage seen. Similarly, disease organisms may cause a variety of symptoms. Know which one you are dealing with so that a timely and appropriate treatment can be applied.

Spotted wilt virus
Section 6 page 28

- **Is the crop susceptible to virus?** Tolerance to a pest may decrease sharply if it carries a virus to which the crop is highly susceptible, for example western flower thrips and tomato spotted wilt virus in dahlias.
- **What is the infestation level in relation to the plant size?** Younger, smaller plants tolerate fewer pests than older, larger plants, and the pests will likely multiply before the crop is mature.
- **What is the overall health of the plant?** Less vigorous plants are less able to tolerate pests and diseases. Cuttings from older plants are more prone to disease. Change stock plants regularly. Excessive nitrogen levels can increase sap-sucking pests such as aphids.
- **What are the climatic conditions at the time?** Pests and diseases develop more slowly at cool temperatures. High humidity and temperature will bring on some diseases faster.
- **How close to flowering is the crop?** Sprays may damage flowers. They need to be applied before coloured-bud stage.
- **Are you using biocontrol agents or have you noticed natural enemies coming in?** If it is early in the crop cycle, you may want to leave some plants untreated to act as nurseries for the biocontrol agents. Remember though, tolerance for a pest does not have to increase because you are using biocontrol. Management is in the timing of the treatment, not in compromising the final quality of the product.

Know your
biocontrol agents
Section 7

What is the likely customer response to the presence of the pest and/or damage caused by the pest?

- **Is the customer likely to notice the pest or damage?** Customers are more likely to notice symptoms of diseases than pests. Sometimes relatively insignificant pests, for example shore flies and fungus gnats, can attract negative attention.
- **How close to market is the crop?** A low pest/disease incidence near market is of less concern than the same infestation early in the crop.
- **Is it a nursery or cut flower crop?** If the plant is to be grown on by the customer, the pest is likely to develop once it leaves the point of sale, whereas a cut-flower crop has a limited life.

Determining an action threshold

Decide what level of damage you are prepared to accept. Be aware of the pest level that will produce this damage. Such things as crop value and pest distribution will affect your decisions.

Example

Two-spotted mite often has a patchy distribution that can produce 'hot-spots' where they first occur. If you are using the Persimilis predatory mite, you may be prepared to hold off spraying even though the spider mite numbers in the 'hot spots' are becoming a concern.

If you can see that over most of the crop there is negligible risk of immediate damage, and that the predator mite population is building in the 'hot spots' and with a little more time will control the entire infestation, spraying can be avoided. Damage to a few plants can be accepted where there are greater benefits to be gained.

Alternatively, isolate the worst affected plants until Persimilis greatly predominate, then use these plants as banker plants to spread Persimilis through the rest of the crop.

Indicator plants

There are some types of plants (including some weeds) that are more susceptible to pest infestation and disease attack than others. Closer attention should be paid to these during monitoring. The attraction of pests to susceptible plants will not prevent all of the cultivars from becoming infested, but rather it allows growers to pick up the early introduction of pests before they become firmly established and cause economic damage. Table 2 displays a range of indicator plants.

Table 2. *Some indicator plants and pests and diseases attracted to them*

Name	Indicator plant(s)
Whiteflies	Tomato, lantana, gerbera, fuchsia, nicotiana, sowthistle
Spider mites	Marigold, rose, parlour palm, bush beans, capsicum
Aphids	Capsicum, fuchsia
Western flower thrips	Gloxinia, browallia, gerbera, ivy geranium, petunia, white clover
Root mealybug	Brachycome, cacti
Root diseases	Alyssum, snapdragon, poppies
Phytophthora	Proteaceae, camellia
Chalara	Pansy, viola
Tomato spotted wilt virus	Petunia, gloxinia, fava beans, dahlia, cyclamen, New Guinea impatiens

Petunia and fava beans, along with non-sticky yellow material such as flagging tape or card to further attract them, can be used as indicator plants for tomato spotted wilt virus, which infects a wide range of ornamental plants. Even though you may not grow petunias commercially, you may be interested in using them as indicator plants. They can be useful in providing an early warning of the threat of this disease, and the need to control the thrips vectors. Look for necrotic spots with lighter centres on the leaves.

Scouts should regularly check indicator plants along with other monitoring duties. If indicator plants are neglected they will become a source of pest infestation or disease infection for your healthy crop plants. Make a list of regular pest and disease problems on your plant lines.

Record keeping

All sticky trap and crop scouting data should be recorded and summarised on proper forms. It is equally important to record full details of all treatments, whether chemical sprays or releases of biocontrol agents. Summary data should be graphed, so that you can follow pest and disease infestation patterns and indicate where sprays and biocontrol agents have been used. If you are a consultant monitoring on someone else's property, leave a grower

report form with the property. The report will highlight pests and diseases and any recommendations for action or not.

Records will allow you to keep track of actions and costs associated with them, so that you can make informed decisions on the need for and benefits of changes. Many basic computer spreadsheet programs, such as Microsoft Excel, can be used to produce record sheets, and make it easy to recall and graph information.

more info
Blank record sheets
Handy Guide 3

Putting it all together

Section 4 has provided a snapshot of monitoring practices. There is much more information on the subject and you are advised to attend an IPM training course to learn more. The National Greenhouse IPM Project funded by the Horticultural Research and Development Corporation has developed a national IPM training course for growers. The course is highly practical and aims to give participants the maximum opportunity to practise identifying pests and diseases, scouting, identifying pests on sticky traps (which can be tricky) and, of course, designing an IPM program and putting it into practice.

more info
The Nursery Papers
1997#005
Section 10 page 8

It may take six to 12 months before you feel confident about monitoring and about these non-chemical management approaches but with effective monitoring, pest problems will be identified sooner. It will also give you the ability to implement changes with confidence.

A three-phase approach to converting your property to IPM is generally recommended. That way, you become comfortable with each phase before going on to the next. Here are the three phases.

Phase I: Setting the scene

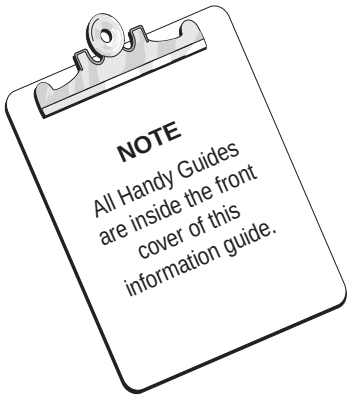
In this phase you need to take stock of your current pest and disease management programs and prepare the property for change.

Training in pest identification should include recognising pests on sticky traps

- **Make a commitment**. Management must be committed to IPM because initially it takes more time and, in some cases, more money. Costs will be returned through more efficient chemical applications and less time-consuming pest and disease management programs.
- **Prepare your property and staff for IPM**. See *Section 3, Preparing for IPM: property and staff* for details on management, staff, site and physical considerations, and adopt the concepts where appropriate. You need to make a serious effort to prevent the entry and spread of pests, diseases and weeds on your property.
- **Become familiar with key pests, diseases and weeds**. Obtain identification aids such as the companion pocket-sized *Pests, Diseases, Disorders and Beneficials in Ornamentals: Field Identification Guide,* see *Section 10 Further reading* page 7 and the Pest Sticky Trap Poster (in the front of this information guide).

  They will help you implement an IPM program. Note the availability of support services for diagnosis and analysis in *Section 9, Directory*.

- **Attend a training course in IPM**. Management and key staff will both benefit.
- **Start monitoring** by using sticky traps and crop inspections. Follow the recommendations given in this section. Set aside a specific time each week for monitoring and involve staff. Talk to consultants about how to set up a program for your operation.
- **Start record keeping**; it will give you a yard stick by which to measure changes in practice. Examples of four record sheets are given in *Handy Guide 3, Record sheets*. Record all pesticide applications and biological introductions on the same sheets. Record product, rate, application method (high volume, low volume, spot spray), date and time of day. Get a handle on the cost of your present spray program.
- **Learn how to make improvements** in the choice of chemicals for your program. Get information on what chemicals are registered for your crop. Refer to *Handy Guide 4, Chemicals currently registered for common pests of ornamentals* and *Handy Guide 5, Chemicals currently registered for common diseases of ornamentals*. For the latest information consult *Section 9, Directory*, Pesticide training courses and information services, page 19. Identify those pesticides that are least toxic to beneficials from *Handy Guide 6, Chemical toxicity to biocontrol agents*.



Phase II: Modifying the spray program

When you have identified the key pests and diseases, their seasonality and life histories, and are confident in monitoring for them, you can start to modify your spray program. The modifications consist of reducing the number of pesticide applications, choosing the best pesticide to apply, applying more specific products using the most appropriate application technology, and adjusting the interval between subsequent applications. Keep in mind that reduced chemical use in an IPM system may lead to some previously minor pests becoming more important; watch for changes.

- **Continue monitoring and record keeping**. Fine-tune both to reduce the time spent without loss of important detail. Can you predict when pests and diseases might occur from last year's records? Determine action thresholds based on this information.
- **Eliminate ineffective** pest management products.
- **Try less toxic pesticides** such as soaps and oils.
- **Time your pesticide sprays to target susceptible life stages of pests.** Your scouting efforts should give you a good idea of when these stages are occurring**.** Understand pest lifecycles; remember lower temperatures slow development.
- **Skip sprays when appropriate.** Apply sprays when monitoring indicates they are needed, not by the calendar. Treating 'hot spots' can save time and considerably reduce pesticide applications.
- **Install insect-proof screening** where appropriate to reduce pest pressure.
- **Learn about the availability and use of alternatives to chemicals**, for example large sticky traps, pheromone traps for moths, biocontrol.
- **Develop a plan to ease into biocontrol**. Seek advice. Prepare the greenhouse environment to maximise your chance of success. Try

more info
Know your pests
Section 5

more info
Physical exclusion of pests
Section 3 page 11

biocontrol agents in limited areas free of pesticide residues so you become familiar with what they can do and what they look like.

Phase III: Implement biological control

Biocontrol agents are not an essential part of an IPM program but they can work well in some situations. The range of commercial biocontrol agents is somewhat limited at present but should increase with demand. Many natural enemies (beneficials) exist in unsprayed habitat and may invade outdoor crops and unscreened greenhouses in substantial numbers. They may be the best beneficials adapted to your particular location. Exploit them! Once you learn to recognise and scout a crop for its pests and natural enemies quickly and accurately, you can start planning whether to supplement natural controls with commercial biocontrol agents where appropriate.

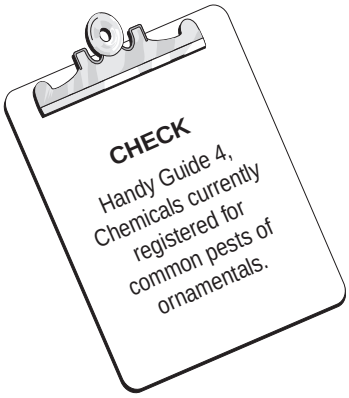
This nursery is protected by regular introductions of biocontrol agents

Biocontrol agents for plant pathogens are also becoming available. Many of the same principles apply to their use.

There are several key steps in developing and integrating natural enemies into your management program.

more info
Know your biocontrol agents
Section 7

more info
The Nursery Papers
1998#007, 1996#008
Section 10 page 8



- **Choose your crop-pest complex.** Note which key pests and diseases are driving your spray program. Are there biocontrol agents that can replace chemicals for these pests? Are there are other pests and diseases that are currently minor but are being held in check by pesticides for the major pest and disease complex? It's best to start with a simple system: one crop with a limited number of pests (such as poinsettias with whiteflies and fungus gnats), or a crop where spider mites are the main pest. Review the information on biocontrol in this information guide.
- **Reduce toxic residues**. Biocontrol agents are sensitive to low levels of some pesticides, see *Handy Guide 6, Chemical toxicity to biocontrol agents* or contact your supplier. Review all records of pesticide applications during the past six months. Ensure that pesticides with long-term residues have not been used during this time. Between crops, wash the inside walls of plastic covers in greenhouses with soap or high phosphate detergent solutions to remove toxic chemical residues. You may need to treat plastic floors and pots. Beware of imported plants with unidentified pesticide histories. Discuss suitable chemicals to be used on propagation material before shipment to your property. If you are unsure, release small numbers of biocontrol agents on a few plants and check for their survival over two to three days. Or put biocontrol agents and foliage of targeted plants in a large jar with a screened lid and check survival for a day (this will not tell you if there are fumes coming off the structural components of the greenhouse).
- **Identify biocontrol agent suppliers and best methods of transport**. Biocontrol agents are living organisms. They are perishable and susceptible to damage in transit. Work with your distributor to determine the quickest and most reliable method of delivery.
- **Determine your introduction rates and times for biocontrol agents**. Work with your biocontrol agent producer or distributor to determine

Bellows are a novel way of spreading predatory mites in bran

the best rate and timing of release for your crop. Biocontrol agents must be introduced early, at the first sign of pest infestation. If there is a strong chance of the pest occurring at a particular time of the year, introduce biocontrol agents beforehand. In the UK, nurseries operate on the basis of introducing biocontrol agents at frequencies and rates that are economically acceptable to waste, that is, a biological insecticide approach, where biocontrol agents are released on a continuous basis. Use higher rates and frequencies until you become more familiar with their performance.

- **Inspect biocontrol agents on arrival.** They may have been exposed to temperature extremes during delivery. Inform your supplier immediately if there are problems so biocontrol agents can be replaced as soon as possible and delivery problems corrected.
- **Release biocontrol agents on receipt;** they are perishable. If biocontrol agents can't be released immediately, hold them at 10 to 20°C until they can be applied to the crop. Apply them as soon as possible (but not during extreme temperatures) and follow the release instructions carefully.
- **Continue to monitor** pests and beneficial insects. Be aware of the appearance of pests and beneficials and record their occurrence in your weekly scouting. Evaluate the progress of the biocontrol agents as well as the pests. If records show a biocontrol agent is ineffective, try to find out why. Alter your program by spot spraying and, if possible, providing more acceptable conditions for the biocontrol agents in question. Keep an eye out for naturally occurring beneficials in your crop.
- **Correct imbalances** with compatible pesticides as needed. Biocontrol is only one type of management strategy in an IPM program. You may need to supplement biocontrol agents with compatible pesticides to reduce pest populations, even though compatible products may have some negative effects on biocontrol agents.
- **Adjust your expectations**. Low pest levels may be unavoidable for a short time, but they may be acceptable at some stages of crop production.
- **Be patient!** Biocontrol is not an instant fix. It is a preventative action, slower to reduce pest populations than chemical control, but often more effective in the long term. There is the added benefit of extending the life of useful pesticides.

Good IPM practices; note numbered trap position, traps correctly positioned, and nearby tomato spotted wilt virus indicator plant with coloured flagging tape to attract western flower thrips

Summary of monitoring steps

- Determine the purpose of the sampling.
- Identify the targets; for example key pests and diseases, and biocontrol agents.
- Decide on the frequency of monitoring.
- Obtain equipment and record sheets for monitoring.
- Assign a trained employee to be responsible for scouting and traps, to be the point of contact for anything found by other employees, and to liaise with the consultant.
- Develop your own action thresholds.
- Vary your monitoring program as you become more confident.